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The Canadian Entomologist

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The Canadian Entomologist

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The Bionomics of a Coleophorid Associated with Asparagus Spears[1]

By Gordon Guyer, Ray Hutson, and Arthur Wells
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East Lansing, Michigan

The first lots of asparagus received at processing terminals in the Shelby, Michigan area in May of 1959, were heavily contaminated with case-bearer larvae of the family Coleophoridae. Various methods were unsuccessful in an endeavor to dislodge the larvae from the spears. As a result, a detailed investigation was initiated to ascertain the origin, life history, and possible control of this insect.

The first specimens were reported May 6, 1959, from fields within five miles of Shelby. Fourteen fields in the area were examined between May 6 and 8 for the presence and magnitude of the population. Four fields were found to contain extensive case-bearer populations and five additional plantings contained moderate numbers of larvae. Larvae were not found in the remaining five fields. There appeared to be a correlation between the amount of weed debris in the infested fields and the distribution of the case-bearer. Clean fields appeared to be free of infestation. Surveys were made in all asparagus growing regions of the state between May 8 and 20 with specimens being collected from fields in the Fennville, Fremont, and Watervliet areas.

On May 6 the insect appeared to be in the last larval instar. During the warm parts of the day the larvae were active on the soil and migrated from spear to spear. Minor feeding scars were observed on some spears. The principal problem resulted when the temperature dropped and the larvae crawled under the bracts and into the heads of the spears (Figure 1). Many larvae returned to the soil and entered the ends of broken stems of the past season's fern growth (Figure 2) or crawled under stones and debris. Phosdrin at the rate of 1/3 pound and DDT at one pound actual insecticide per acre were ineffective in controlling the insect.

By May 20 all migration had ceased and those specimens which had returned to the old asparagus stems had pupated. Frequent observations were made in the infested fields during the summer without any evidence of further development of the insect. On August 3, 1959, adult specimens emerged from samples maintained in the laboratory. On August 13 extensive populations of adults were observed in many of the fields previously infested.

Adult specimens provided materials suitable for taxonomic determination. The insect was identified[2] as *Coleophora amaranthella* Braun. Braun in her original description of this species (Braun 1919) indicated that the larvae were amaranth-feeders with adult activity coinciding with the blooming of the host plant. The type specimens were reared from seeds of the pigweed, *Amaranthus hybridus* L., collected at Cincinnati, Ohio.

On October 13, seed heads of the rough pigweed, *Amaranthus retroflexus* L., found in one of the spring infested asparagus fields were observed to be

[1]Journal Article No. 2631 approved for publication from the Michigan Agricultural Experiment Station.
[2]Appreciation is extended to J. H. McDunnough of the Nova Scotia Museum of Science, Halifax, Canada, for identification and for his sincere interest in this investigaton.

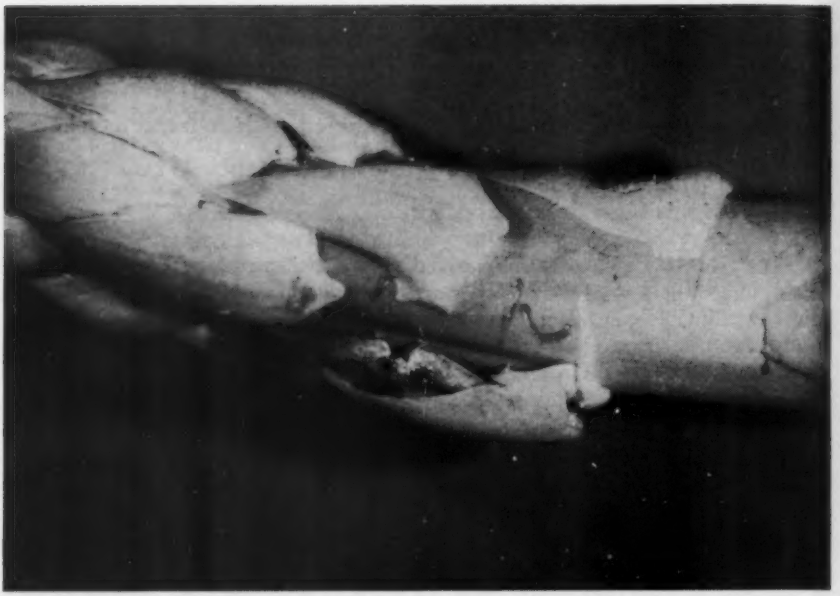

Fig. 1. Asparagus spear showing case-bearer larvae under the bracts.

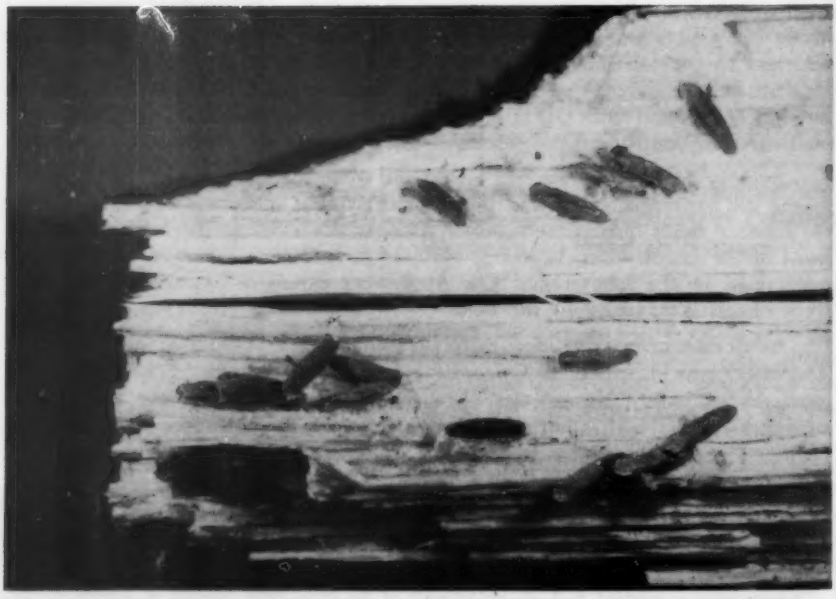

Fig. 2. Old asparagus stem broken open to show overwintering case-bearer larvae.

Fig. 3. Seedhead of *Amaranthus retroflexus* L. infested with case-bearer larvae.

heavily infested with case-bearer larvae (Figure 3). Extensive populations were evident wherever the pigweed was found in the Shelby area. Many larvae were migrating from the pigweed heads to the soil and entering broken asparagus stems and debris. During the fall, the case-bearer was found associated with *Amaranthus* plants in many areas of the Lower Peninsula of Michigan.

As a result of these observations, a weed control program has been initiated to remove the *Amaranthus* plants from Michigan asparagus fields and thus eliminate the necessity for chemical control activities.

Reference

Braun, A. F. 1919. Descriptions of new species of *Coleophora* (Microlepidoptera). *Ent. News* 30: 129.

(Received May 28, 1960)

Life History of the Pine Tip Moth, *Rhyacionia adana* Heinrich, in Ontario (Lepidoptera : Olethreutidae)[1]

By J. Lynton Martin
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Infestations of *Rhyacionia adana* Heinrich have almost certainly been common in young pine plantations throughout southern Ontario for a number of years, but, because resultant tree damage has been confused with that of the European pine shoot moth, *R. buoliana* (Schiff.), the species itself has been overlooked.

Although *R. adana* was described in 1923 (Heinrich, 1923), the seasonal history has never been worked out, and even the host plants were not recorded until 1959 (Martin, 1959). In 1957, a study program was begun to learn the life history and habits of the species in Ontario, the results of which are presented here.

Descriptions

Adult

Alar expanse 15 to 17 mm., ground colour of fore wings grey, bearing four pairs of grey-white, vertical bars. Outer third of fore wing red. Hind wings smoky fuscous. This species is similar in colour to several others in the genus, but it can be readily separated by its aedeagus which is smooth and tapers to a long, curved tip (Fig. 1).

Egg

Circular, 0.75 mm. in diameter, with yellow, pebbled surface.

Larva

The newly-hatched larva is about 1 mm. in length, the body is pale yellow, and the head capsule, prothoracic shield, and anal plate are brown. When mature, the larva reaches a length of 7.5 mm., the head capsule is dark brown to black, prothoracic shield black, and the anal plate is dark brown in living specimens. The remainder of the body is light yellowish-brown to reddish-brown. The crotchets are unevenly uniordinal, and there are 16 to 20 on the ventral and 11 to 13 on the anal prolegs.

Pupa

The pupa is about 6 mm. long and 2 mm. wide. When first formed, it is light yellow, but later the head, thorax, and wings become dark brown, and the abdomen brownish-yellow. The head bears a broad, pointed beak. There are two transverse rows of spines on the dorsum of abdominal segments 2 to 8. The spines of the posterior row of segment 8 are few in number, and segment 9 bears only two or three spines. The cremaster has a number of spines which have their tips curved anteriorly.

Distribution and Hosts

The material for Heinrich's original description (Heinrich, 1923) came from Massachusetts, Virginia, and Pennsylvania, and the species has been reported from Michigan and Wisconsin[2]. In Ontario, it is found throughout the southern and central regions, and as far west as the Port Arthur District.

R. adana feeds upon young red pine, *Pinus resinosa* Ait., jack pine, *P. banksiana* Lamb., and Scots pine, *P. sylvestris* L., usually under three feet in height, in nurseries, plantations, and natural stands.

[1]Contribution No. 628, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

[2]Personal communication from P. R. Flink, Dept. of Conservation, East Lansing, Michigan.

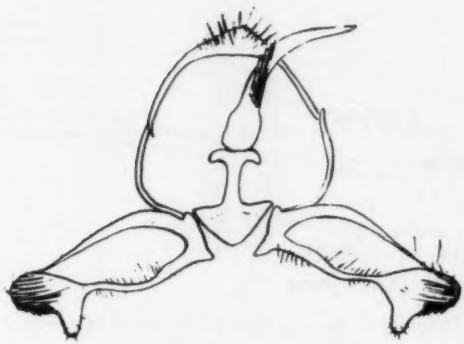

Fig. 1. Male genitalia of *R. adana*.

Life History and Habits

R. adana overwinters as a pupa attached to the tree at the root collar, immediately beneath the soil surface. About the middle of April, when daytime temperatures reach a high of about 50°F., the pupae break through the upper end of the cocoon, and wriggle upwards to the ground surface. Here the moths emerge and crawl up on the trees. Adults were first seen on April 19, 1957, April 12, 1958, and April 15 in 1959.

The flight period of this insect is particularly interesting because of the time of year at which it occurs. When the adults emerge, there are still patches of snow on the ground, and the weather is quite unreliable. Some snow storms occur, rain and high winds are common, and wide ranges of temperatures within short periods are the rule. As a result, days with conditions suitable for adult activity may be quite widely separated by intervals of bad weather.

Copulation and oviposition occur on fine days when the temperature is at or above 60°F., usually between 1 and 8 p.m. When the temperature falls, as it usually does during the night, the moths drop to the ground and remain there in a torpor until it rises to 60°F. once more.

Copulation takes place on the trees, and the moths remain paired for two to 18 hours. Oviposition may begin 12 to 24 hours after mating. The female crawls down the needle fascicle, inserts her abdomen between the needles just above the needle sheath, and lays usually one but sometimes as many as four eggs on the inner side of the needle (Fig. 3). Approximately 30 seconds are required to lay one egg, and two, three, or four eggs are often laid in rapid succession on different needle clusters, after which the female rests for a long period before moving to another tree. The moths are fairly strong fliers, and may visit a considerable number of trees over quite a large area before they have laid their complement of eggs.

When first deposited, the eggs are yellow, but after five days they change to dark orange-brown; they hatch in about three weeks. The young larva, about 1 mm. in length, spins a thin silken case between the two needles just above the sheath (Fig. 2), and lies within this case while making entry into the needle.

The larva enters the needle on the inner side immediately above the point where the egg was laid. It feeds towards the tip, usually along one side but sometimes mines the whole diameter of the needle (Fig. 2). The first-instar

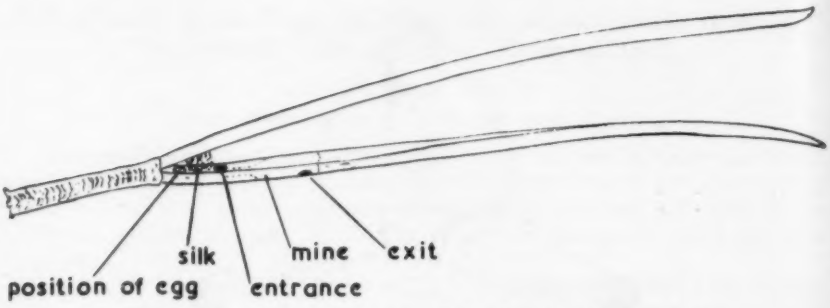

Fig. 2. Oviposition site and mine of *R. adana* in red pine needle.

larva pushes the frass out of the mine, and a small accumulation can usually be seen on the needles, but the second-instar larva leaves the first-instar head capsule and the frass in the mine. The amount of mining done by the second-instar larva is variable; at times they will leave the mine immediately after moulting, but in other cases they will continue to feed in the needles for several days. The completed mine is from five-sixteenths to one-half inch in length, and departure is made either through the entrance hole or by way of an exit hole on the outer side of the needle.

Early in June, the larvae leave the old needles to attack the new shoots. At this time the shoots are from one to two inches in length, and the young needles are about one-half inch long with only their green tips showing beyond the end of the sheath. Feeding begins at the base of the young needles within the sheath, and if there are only one or two larvae per shoot, this method of feeding may continue throughout most of the larval life. The insects move from one needle cluster to the next eating only the tissue within the needle sheath and the new green bark of the shoot in the immediate vicinity of the fascicle.

However, if more larvae are present, the external type of feeding is followed by tunnelling in the shoot itself, until it is completely riddled. Just before leaving the shoots, the larvae move to the tips and destroy the new buds set by this time for the following year.

A close examination is necessary to determine the presence of this insect throughout the feeding period. The infested shoots appear somewhat stunted compared with healthy shoots, but there is little loss of colour, and only a careful scrutiny reveals the frass embedded in the pitch among the needles. However, after the larvae have finished feeding, the growth differential between healthy and infested shoots increases rapidly. The infested shoots eventually die, turn brown and brittle, and crumble readily under a light pressure.

About the end of June, the larvae crawl down the shoots and enter the soil. Just beneath the surface, the larva chews a tiny hole in the bark of the tree, and immediately below this hole it begins to spin a silken cocoon. Pitch flows from the hole in the stem, and the larva mixes this with a blood-red secretion from its mouth, and smears the mixture over the silken walls of the cocoon. The mixture solidifies to form a dry, hard casing, usually pure white, but sometimes with a slight pinkish cast. The cocoon, cemented quite firmly to the stem of the tree, is coated with soil particles on the outside (Fig. 3). The larva becomes shorter and stouter, and about August 1 it transforms to a pupa.

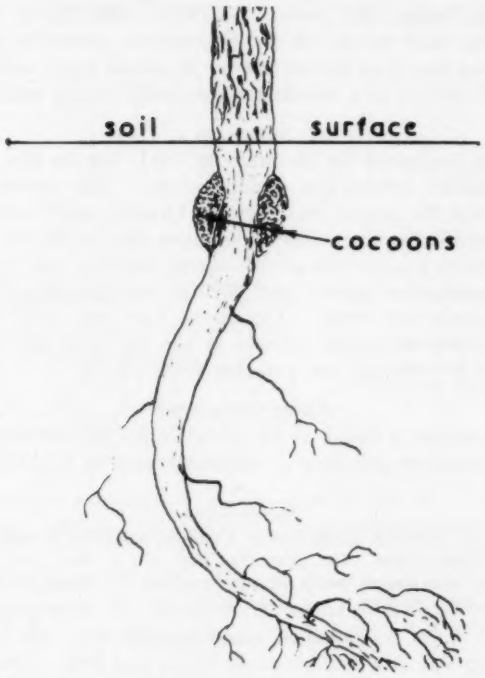

Fig. 3. Cocoons of *R. adana* attached to young red pine.

Parasites

Three species of hymenopterous parasites were reared from collections of *R. adana*: *Trichogramma minutum* Riley, an egg parasite; *Earinus zeirapherae* Wly., a solitary larval parasite; and *Bracon mellitor* Say, a gregarious larval parasite.

The attacks of *E. zeirapherae* and *B. mellitor* resulted in a mortality of 10 to 55 per cent in the prepupal and pupal stages at various locations in 1958.

Discussion

Mixed populations of *R. adana* and *R. buoliana* are often found in young, red-pine stands in southern Ontario, and although the larvae are closely similar, the two species can usually be separated quite easily in the field. Since *R. adana* attacks only young trees, mixed infestations will rarely be found in plantations over 5 or 6 years of age.

The timing of the two species differs, and when the larvae of *R. adana* enter the shoots early in June, the larvae of *R. buoliana* are either mature or in the pupal stage. The difference in larval size at this time is considerable. *R. adana* pupates in a cocoon attached to the root collar of the tree near the end of June, whereas *R. buoliana* pupates in the damaged shoot from mid-May to early June.

The damage resulting from the feeding of the two species differs in that *R. buoliana* enters the shoots before needle growth has begun, and although shoot elongation often continues for a time, the needles rarely begin to grow before feeding is finished. *R. adana*, on the other hand, enters the shoots after

needle growth has begun, and growth continues until shortly before the shoot is destroyed. The dead shoots left by *R. buoliana*, therefore, usually show no needle growth, but the dead shoots left by *R. adana* bear needles about 1 inch in length, and the shoots as a whole are extremely brittle and crumble readily.

Summary

R. adana was described by Heinrich in 1923, but its life history and host plants were unknown before the present study. This species is found from Virginia northward to central and western Ontario, and feeds on young red pine, jack pine and Scots pine under about three feet in height.

It overwinters as a pupa, the adults emerge and lay their eggs in mid-April, the first- and second-instar larvae mine needles, and the rest of the larval period is spent in the shoots and buds. The larvae leave the buds to pupate in the soil in late June, and the pupae remain in the soil until the following spring. Three species of hymenopterous parasites were reared.

Acknowledgments

The author wishes to thank D. G. Grisdale for his extremely helpful assistance in the field, and the advice and encouragement of R. M. Belyea was much appreciated.

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(Received March 30, 1960)

A Portable Photoelectric Detector of Flying Insects[1]

By E. Argyle[2] and J. Chapman[3]

Richards (1955) detected insects in flight while studying changes in the amount of radiant energy from the sun. His report stimulated our consideration of a method specifically intended to record insect flight activity. We wished, by means of a portable and relatively simple apparatus, to detect and count insects flying through a given space. The method developed differs somewhat in principle from that of Richards. In his apparatus the effect of an insect was to decrease slightly a large amount of energy continually falling on a photoelectric cell. Our method utilizes light reflected from an insect to a photoelectric cell which otherwise views a black background.

Our device may be described as follows (see Fig. 1). A photoelectric cell is mounted in a light-tight box in such a way that it views, through a narrow slit, a larger slit in another box. The boxes are painted inside with flat black paint and have internal baffles to reduce light diffusion. They are held in alignment by narrow boards and are carried and used together as a unit. An insect flying past the field of view of the photoelectric cell reflects a certain amount of light to it. This is converted into an electrical impulse, amplified and used to operate a relay which in turn actuates a register (counter). The number of insects flying through the space between the slits of the boxes can thus be counted for any given interval of time.

[1]Contribution No. 650, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

[2]Dominion Radio Astrophysical Observatory, Dept. of Mines and Technical Surveys, Penticton, B.C.
[3]Research Branch, Dept. of Agriculture, Forest Biology Laboratory, Victoria, B.C.

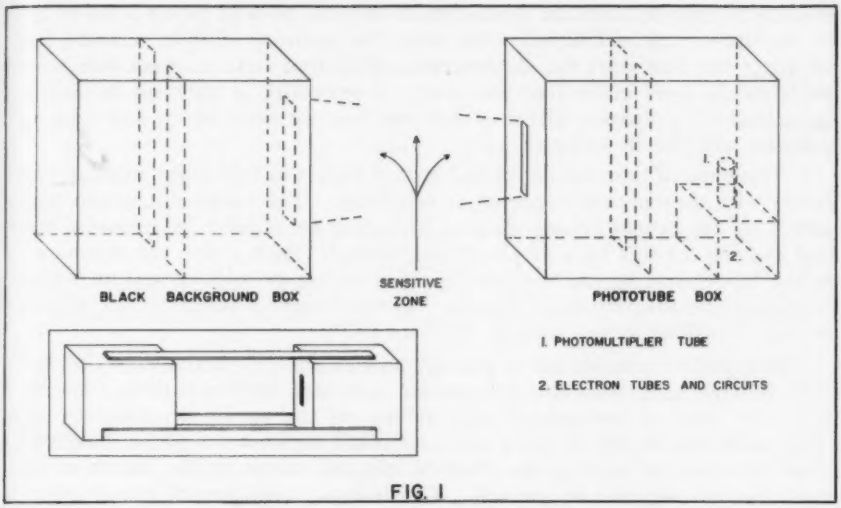

Fig 1. Diagram of photoelectric insect flight detector.

The electronic circuits are battery operated and miniature tubes (type 1U4) are used. The equipment may be operated in the field for several dozen hours without changing the radio-type batteries. Batteries, relay and register are mounted in a separate small box which is connected with the photoelectric tube box when operation is desired. While no details of the simple electronic circuits will be given here one feature is worthy of note. · The electrical impulses from the photoelectric cell are fed through a potentiometer sensitivity control first to a univibrator (Seeley, 1958). This changes from one stable condition to another with each input impulse of sufficient strength and provides, through a single stage amplifier, strong, positive drive for the relay which actuates the register. The entire electronic circuit with batteries occupies a small space and weighs only a few pounds. Use of transistor circuits could further reduce weight and increase battery life.

Richards mentioned that his apparatus detected insects which were not seen visually, but he did not give specific detection distances. His equipment distinguished the oscillations produced by the effect of the insects' wings on the radiant energy reaching the photocell. By feeding the photoelectric cell output of our unit through an amplifier to an oscilloscope we, also, can note the effects of wing beat, although with the circuit actually used the passage of an insect is recorded simply as a single count.

Our detector can be made extremely sensitive as will be mentioned later, but operates effectively only when the boxes containing the photoelectric cell and the black background slit are not too far apart (3 1/2 feet in the unit constructed). This limitation involves not only the necessity of having the slits on both boxes correctly aligned, which is most simply done by joining them into a single unit as mentioned previously, and of having the background slit larger and larger for greater and greater distances between the boxes. The most important factor in this connection follows from the fact that each detected insect acts as a source of light, and the intensity of light received from it varies inversely as the square of its distance from the photoelectric cell. In practice, control of

the size of impulse from the photoelectric cell can be used to set a lower limit to the size of insects counted. But, since the intensity of light received from an insect two feet from the photoelectric cell is four times as great as it would be from the same insect four feet away, if sensitivity is sufficient to detect a large insect at a distance of several feet then near-by small insects and even dust particles will also be counted.

This type of unit can detect and record insects in free flight without interfering with their normal responses or behaviour. The visual obstruction represented by the boards linking the two boxes can be avoided by removing them and aligning the slits by a simple optical method. Such a unit can also be used in the laboratory, to measure activity of crawling or walking insects without influencing or affecting them directly. In this respect it resembles the infra-red activity recording system used by Brown (1959).

In regard to possible use of this unit as a laboratory activity recorder, however, it must be stressed that for suitable detection sensitivity there must be a very low level of background light falling on the resting photoelectric cell. This means that a cage or other means of confining insects must be designed to avoid reflection of light to the photoelectric cell except by the insects as they cross the viewing area of the cell. To illustrate, with general illumination of 140 foot-candles and using an IP21 photomultiplier tube, with 620 volts applied, *Drosophila melanogaster* were consistently detected out to five feet from the light sensitive surface but when either black building paper or a dark blue or black cloth was substituted for the black background slit, the loss of sensitivity, due to reflection of some light, was such that the far larger blowfly, *Phormia,* was not detected even at two feet. The reason for this is that the greater the background light the less change there is in current from the photoelectric cell as a result of light reflected from a passing insect and the less the contrast between signal and no-signal conditions. The sensitivity of detection is greatly reduced by stray light and the black boxes with slits, and light baffles within, are a very important feature of the method.

Because of their much greater sensitivity to light, photomultiplier rather than single-stage photoelectric tubes were used. The former require from 500 to 1,000 volts but this can be supplied by miniature batteries, whose life for such an application is essentially shelf life. Three different tubes have been tested, one IP21 and two 931A's (R.C.A.). The former is more expensive but also much more sensitive. By using the higher voltages the sensitivity of the 931A's can be increased so that they are suitable for most applications, however. With both types of tubes, sensitivity increases greatly with increases in applied voltage.

Many performance tests were made at different light intensities by placing the unit on its side and dropping dead specimens of various insects through the viewing path at different distances from the photoelectric tube. The upper limit of sensitivity is that at which air-borne dust particles are counted. This limit was reached, with the IP21, at 120 foot candles with 720 volts applied, or at 30 foot candles with 820 volts. Just below this level of sensitivity *Drosophila* and even ceratopogonids (no-see-ums) were consistently counted at a distance of five feet from the photomultiplier tube. One of the 931A tubes showed almost equal sensitivity at 120 foot candles with 820 volts applied but the other did not attain such sensitivity even at 1010 volts. This illustrates the considerable difference in the performance of individual tubes of this type.

The flight detector can be used in several ways in connection with ecological studies on insects. To illustrate, one day in July, 1959, it was placed beside a

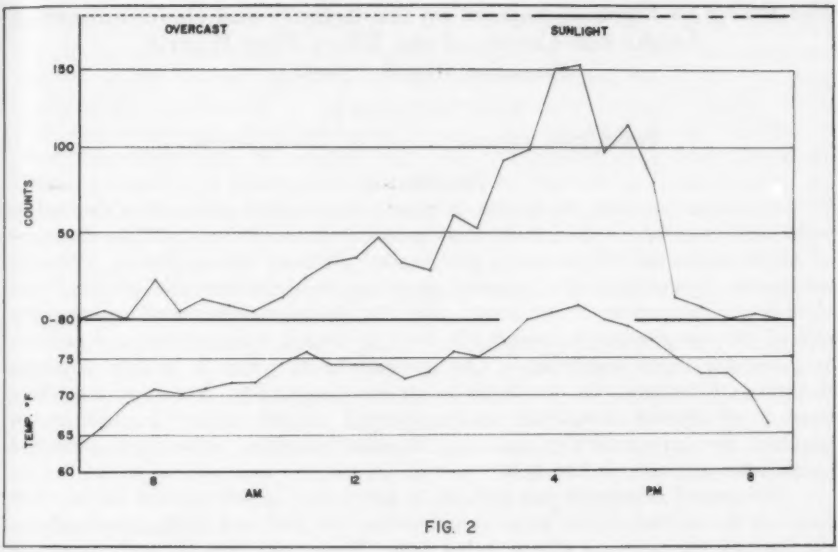

Fig. 2. Number of flying insects counted for ten minute intervals each half hour during the day, in relation to sunlight and temperature. Detector unit beside wild carrot (*Daucus*) blossoms, July, 1959.

few blossoms of wild carrot (*Daucus*) near Parksville, B.C., and counts of flying insects recorded for 10-minute periods at each half-hour interval throughout the day. The resulting counts are shown in Fig. 2. No allowance has been made for coincidence effects but this would be necessary at high counting rates.

It is apparent from the information given that such a unit cannot distinguish between various types of insects except to a certain extent by size. It would be possible, by adjusting photoelectric tube or circuit sensitivity, to count only insects above a given size, but the sensitivity would have to be varied with changes in light during the measurement interval in order to secure consistent results. Also, rain drops, falling needles or drifting plant seeds are not distinguished from flying insects. If, however, visual observations are made during use, to aid interpretation of results, or if used indoors under controlled conditions, such a unit can furnish quantitatively reliable data.

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(Received June 1, 1960)

The Effect of Physical Factors on the Activity and Development of Adults and Larvae of the White Pine Weevil, *Pissodes strobi* (Peck)[1]

By C. R. SULLIVAN
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Introduction

This paper presents the results of quantitative studies designed to determine, under field conditions, the influence of weather on the activity and development of adults and larvae of the white pine weevil, *Pissodes strobi* (Peck). The investigation forms part of a general program to determine the physical and biological requirements of the insect, with the ultimate objective of assessing the role of the environmental complex in limiting weevil development and survival to particular stand conditions. The problem arose when it became apparent that this information was pertinent to studies designed to determine the effectiveness of applied silviculture in the control of the insect. In addition, it provided the opportunity of assessing the effectiveness of applying quantitative bioclimatic methods in the field.

The weevil completes one generation per year. It overwinters in the adult stage on the surface of the mineral soil within the duff and litter, commonly at the base of the trees on which it last fed. The adults pass through an active period of about two months before they enter hibernation, and upon resumption of activity the following spring, they pass through a second active period of about two months, during which time the eggs of the succeeding generation are deposited in the leaders of the host tree. Marked differences in their behaviour and activity occur during these periods that necessitate treating the two age groups separately. Therefore, to simplify reference to these age groups, and to comply with the terminology of earlier publications, they will be referred to as autumn and spring populations.

Materials and Methods

The work reported herein was carried out in young, open growing stands of white pine, *Pinus strobus* L., located within plantings of the Petawawa Forest Experiment Station, Chalk River, Ontario. Periodic observations of the activity and behaviour of the adults were made during the spring and autumn. Four major types of activity by adults of the spring population were noted and classified: feeding, copulation, oviposition, and inactivity. Activity of the autumn population of adults was limited mainly to feeding. Hourly observations of activity during type days (cf. Wellington (11)) were made on populations on a number of trees. Meteorological observations were made in conjunction with the biological observations using the equipment and methods described in an earlier paper (9).

During spring, observations were limited to the leading shoots of white pine because the adults confined their activities to this portion of the trees. It was soon found that the important physical factors affecting weevil activity were temperature and atmospheric moisture. Percentages of the insects observed engaged in the activity types noted above, at various levels of air temperature, white pine leader bark temperature, and relative humidity were used to show the effects of these factors on weevil activity. Since the observations were carried on over consecutive years, it was necessary to determine whether or

[1]Contribution No. 629, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada; based on part of a thesis submitted as partial fulfilment for the degree of Doctor of Philosophy at Macdonald College, McGill University, 1957.

not insects of different generations reacted similarly to the factors involved. No significant differences were found between the "b" values of regression analysis of the various activities on the physical factors from year to year. Furthermore, examination of the mean square of error values gave similar results with one exception: borderline significance was obtained in the relation of percentage copulation on relative humidity, presumably as a result of an insufficient number of observations during the first year of the investigation. In addition, the amount of oviposition observed during the first year of observation was not sufficient to warrant treatment in this manner. In most instances, however, grouping was justified. Therefore, a total of 7,592 observations of individual weevil activities were used to show the relation between insect activity and spring weather factors.

During the autumn, activity is limited mainly to feeding which occurs on lateral as well as terminal shoots and on new and old growth. Consequently, it was necessary to examine whole trees critically to locate the insects and to classify their activity. This is time consuming and, as it provides little or no assurance of success, additional records were obtained by inspection of caged trees containing a known number of insects. A total of 3,959 observations on the activity of individual insects were made in conjunction with the existing weather conditions.

Field records were also obtained to show the influence of physical factors of the environment, particularly temperature, on larval developmental rate. Because it is characteristic of the larvae to spend their entire developmental period within a leader, they cannot be directly observed. However, their feeding behaviour provides a means of assessing their growth. Soon after hatching the larvae form a ring about the leader and move down it by feeding on the inner bark while leaving the outer bark intact. The position of the ring of feeding larvae, which is readily detected by the discolouration and texture of the outer bark, was used as a criterion of development. The observations consisted of recording the amount of movement within individual leaders by marking the consecutive position of the feeding ring with pins and measuring the distance between marks. The measurements, taken at two-day intervals, were recorded with corresponding meteorological observations.

Results

Adults

Spring population

Upon emergence from hibernation the adults move up to the leading shoot of the host tree. The behaviour pattern associated with this movement and the subsequent responses of the adults, which tend to keep them at this location throughout varied weather conditions, have been described in detail elsewhere (9). It is sufficient to mention here that the survival and multiplication of the insect is dependent upon its ability to maintain a position on the leading shoot, particularly for the purpose of oviposition.

Once on the leader, the amount of feeding, copulation, oviposition, or inactivity observed during any given period is a function of the existing climate. Within reasonable limits, factors such as wind seem to have little effect on the amount of weevil activity. Heavy rain halts all activity, although a small percentage of the insects may remain active during light rain. The most important elements influencing the extent and type of activity are bark temperature of the leader, solar radiation, and atmospheric moisture, with bark temperature having the greatest regulatory function. Solar radiation affects the body temperature

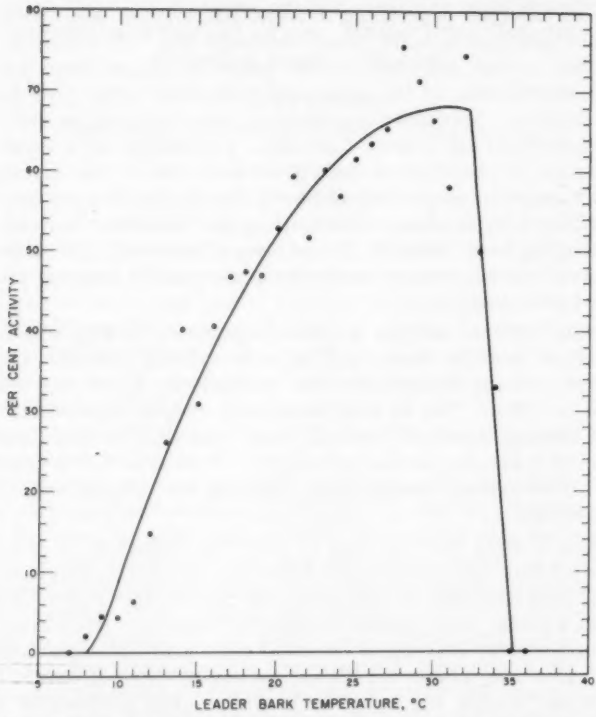

Fig. 1. The effect of white pine leader bark temperature on the intensity of activity of adults of the spring population of *P. strobi* : second degree polynomial fitted between 7 and 32°C.

of the adults, but it affects the bark temperature of the leader in much the same way. The two temperatures are maintained within about 2°C of one another, with the body temperature of the insects being higher. Therefore, solar radiation has not been treated in as much detail as bark temperature and atmospheric moisture.

In general, curved lines best expressed the relations between insect activity and weather elements. On occasion, however, it was observed that a single line did not adequately express the responses of the adults over the entire range of bark temperatures. When this occurred the data were divided at that temperature beyond which further temperature increases were accompanied by a reduction in activity, and a second curve was calculated to express the effects of high temperatures on activity. Since few of the activities showed simple straight line relationships with the factors involved, orthogonal polynomials were fitted to most of the data.

Weevil activity in the spring increases with ambient air temperature up to approximately 28°C, above which much variation occurs indicating the interaction of a number of factors. As Wellington (10) has shown, however, the internal body temperature of insects and the surface temperature of many feeding sites may be elevated by insolation well above ambient air temperatures on clear days. This is so with spring populations of the white pine weevil and it has been found that the bark temperature of the leader, with which the insect is in

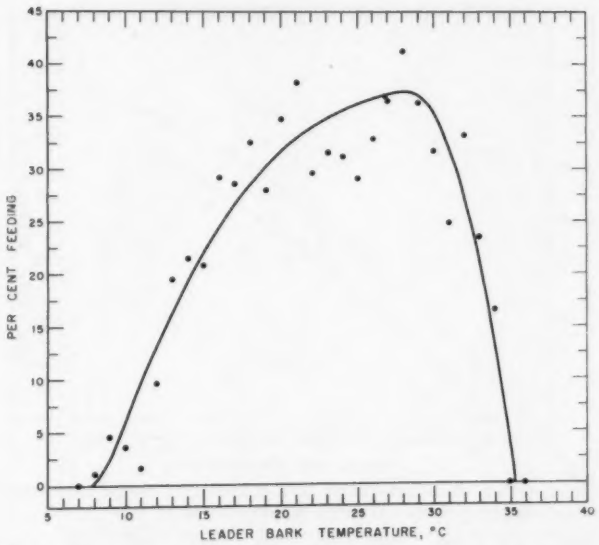

Fig. 2. The effect of white pine leader bark temperature on the frequency of feeding activity of the spring population of *P. strobi* adults : second degree polynomials express the rate of increase in feeding intensity between 7 and 30°C, and the rapid decrease in feeding intensity from maximum to zero.

contact, controls its activity to a higher degree than ambient air temperature. The relationship between total weevil activity (i.e., oviposition + copulation + feeding) and bark temperature is shown in Fig. 1. Weevil activity increases with bark temperature up to about 32°C, above which it decreases rapidly to zero by 35°C.

The regressions of percentage feeding, copulation, and oviposition on the bark temperature of the leader are shown in Figs. 2, 3, and 4, respectively. Fig. 2 shows the marked increase in per cent feeding between 8 and 29°C. Below 8° no feeding occurred and between 29 and 35°C, feeding activity decreased rapidly. The rapid increase in percentage feeding at the lower end of the temperature scale indicates that a large percentage of the insects may engage in this activity over a wide range of bark temperature. The increase in percentage copulation (Fig. 3), although not rapid, occurred at a relatively steady rate between 8 and 33°C. However, the percentage of the population engaged in oviposition activity (Fig. 4) rose exponentially between temperatures of 10 to 29°C, but decreased rapidly between 29 and 35°C. It is also apparent that very little oviposition occurs below 20°C, so that there is only a narrow range (ie., 20 to 29°C) in which bark temperatures are really conducive to this behaviour—a significant fact for interpreting population differences in different types of stands.

Atmospheric moisture also affects the activity of spring adult populations, but to a smaller degree than temperature. Fig. 5 shows the regression of per cent activity on relative humidities between 20 and 100 per cent; as the humidity rose the percentage of weevils engaged in feeding, copulation, and oviposition decreased until only about 7 per cent were active in saturated air. Additional analysis indicated, however, that this relation was at least partially reflected

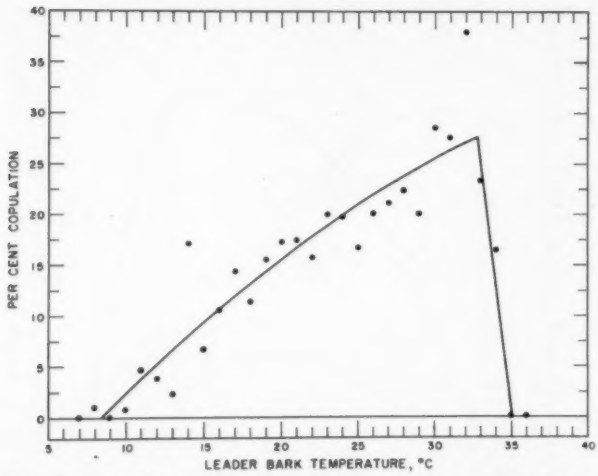

Fig. 3. The effect of white pine leader bark temperature on the frequency of copulation of *P. strobi*: second degree polynomial fitted between 7 and 32°C.

in the temperature-activity relations. This was demonstrated by relating relative humidity and air temperature; the results, based on weighted averages of the relative humidity records taken in conjunction with observations on insect activity, gave a correlation of 0.934. Although temperature is the main governing element, unusual combinations of temperature and humidity occur, so that on occasion their influence on weevil activity cannot be fully described by correlations between the responses of the insects and individual factors of the environment. Therefore, activity isopleths have been drawn between axes of bark temperature and relative humidity to show the effects of these factors acting together to control adult weevil activity. The first of these is shown in Fig. 6.

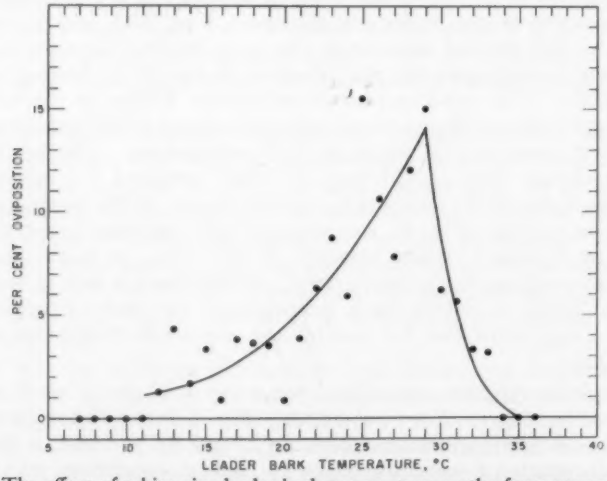

Fig. 4. The effect of white pine leader bark temperature on the frequency of oviposition of *P. strobi*: second degree polynomials express and increase in oviposition intensity between 11 and 29°C, and the decrease from maximum to zero intensity between 29 and 34°C.

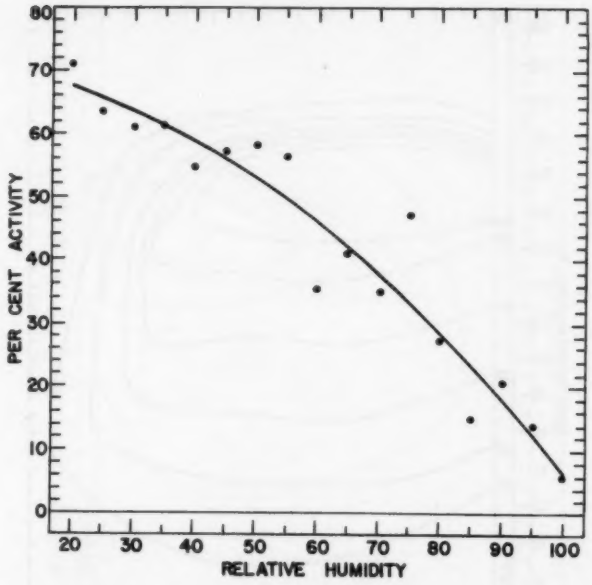

Fig. 5. The effect of relative humidity on the intensity of activity of the spring population of *P. strobi* adults: second degree polynomial fitted.

Fig. 6 shows that the influence of relative humidity on weevil activity becomes more evident at the higher bark temperatures. For example, at a temperature of 31°C, 80 per cent activity occurs over a relative humidity range of 25 to 65 per cent, but at humidities above 65 per cent the amount of activity drops progressively until no weevil activity occurs at about 90 per cent relative humidity. On the other hand, at a constant temperature of 20°C, the amount of activity never exceeds 50 per cent, but this level of activity may occur over a relative humidity range from 20 to 86 per cent. In general, these data show that spring weevil activity is greatest during clear, warm, and relatively dry weather.

Fig. 6 described the influence of temperature and humidity on the general activity of weevil adults. However, the conditions under which the insects oviposit are of prime importance also, since it is known that considerable feeding and copulation take place on pine leaders in shaded stands where eggs are seldom deposited (1). Therefore, one specific activity type, oviposition, has been selected for further illustration because its variation with temperature alone indicated that its limitation was one major factor barring the insect from many white pine stands. Isopleths indicating the variation in percentage oviposition with bark temperature and relative humidity are shown in Fig. 7. This figure shows that oviposition most commonly occurs at temperatures between 25 and 29°C, when this range is associated with relative humidities from 20 to 55 per cent — a comparatively narrow range of each factor.

Autumn population

Activity of the autumn population of weevils is limited to feeding, which continues until hibernation. Feeding activity is not, however, confined to the leader during the autumn as it is during the spring. Field observations on the

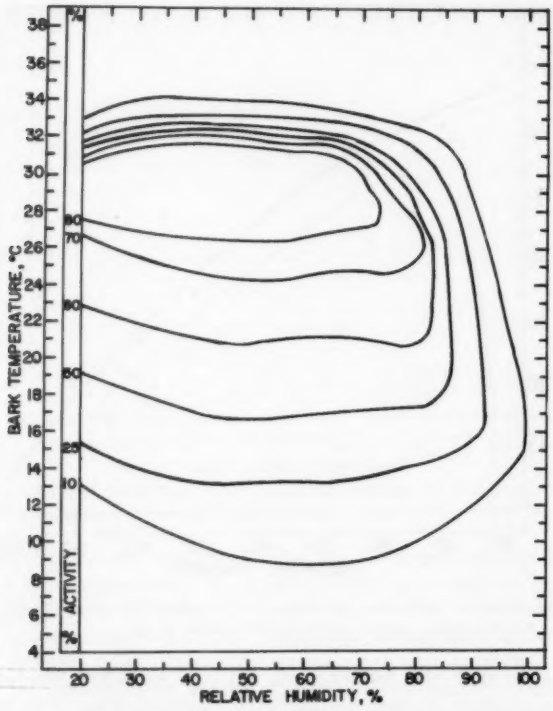

Fig. 6. Activity isopleths showing the combined effect of white pine leader bark temperature and relative humidity on the intensity of activity of *P. strobi* adults of the spring population.

incidence of feeding indicate that about 25 to 30 per cent occurs on the new and previous year's terminal growth of the main stem. The remaining 70 to 75 per cent occurs on the lateral shoots, where preference is shown for the outer three whorls, particularly the new growth and the growth of the previous year. These locations are normally the most exposed and their selection as feeding sites is in accordance with the positive response of the insects to light (9). It is not uncommon, however, to observe adults feeding on older growth produced as much as three years before, and occasionally they have been observed feeding on lateral growth laid down five years previously.

During this study, extensive rearings of young adults under insectary conditions were carried out in conjunction with observations in the field. At no time was copulation or oviposition by autumn adults observed. In addition, pine stems containing approximately 2,500 punctures were examined over a three-year period and in no instance was an egg discovered.

During the field studies, it was found that autumn weather influences the activity of the insects in much the same manner as it does during the spring, with two notable exceptions. First, the insects are less sensitive to changes in atmospheric moisture. No major change occurs in the response of the insects at relative humidities between 30 and 80 per cent. Between 80 and 95 per cent, the percentage of the population engaged in feeding decreases slowly, but as the air becomes saturated the percentage feeding drops sharply to about three per

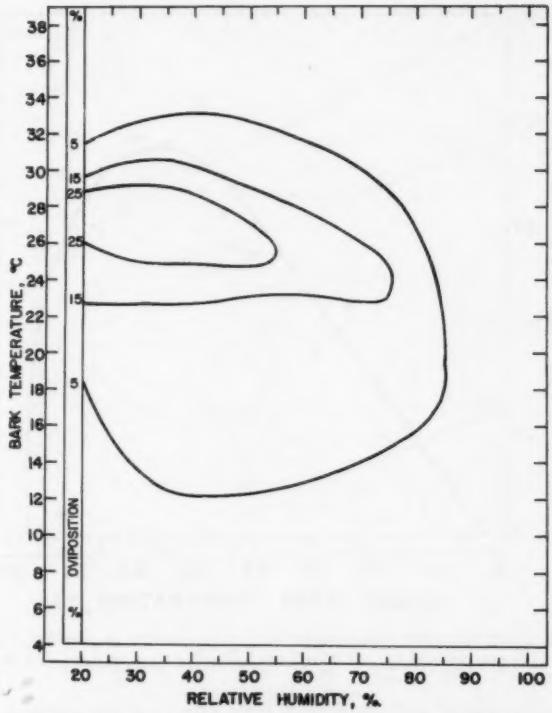

Fig. 7. Activity isopleths showing the combined effect of white pine leader bark temperature and relative humidity on the frequency of oviposition of *P. strobi*.

cent. Secondly, no significant correlation could be obtained between solar radiation and the percentage of the population engaged in feeding activity. This might be expected since considerable feeding occurs on the older growth located in shaded areas within the habitat.

Temperature is again the most important factor influencing feeding by autumn weevil populations. Fig. 8 shows the regression of percentage feeding on the bark temperature of the leader. Feeding activity drops off slowly between bark temperatures of 26-34°C, in contrast to the rapid decrease in activity of spring populations at these temperatures. The explanation for this lies in the responses of the insects to light and temperature, together with the method of observation. It will be remembered that bark temperature of the leading shoot was chosen as the temperature to which activity was related. In addition, observations revealed that at temperatures above approximately 27°C the adults responded photonegatively, moving to more shaded and hence cooler sites where feeding was continued. Thus, while Fig. 8 shows that a high level of feeding continues between 26 and 34°C, weevils were actually feeding at lower bark temperatures than the standard used for comparison.

Larvae

The entire developmental period of *P. strobi* larvae is spent within the leader; they feed on the entire cortex, with the exception of the outer layer of bark, so that they are not directly exposed to the surrounding elements. Weather factors

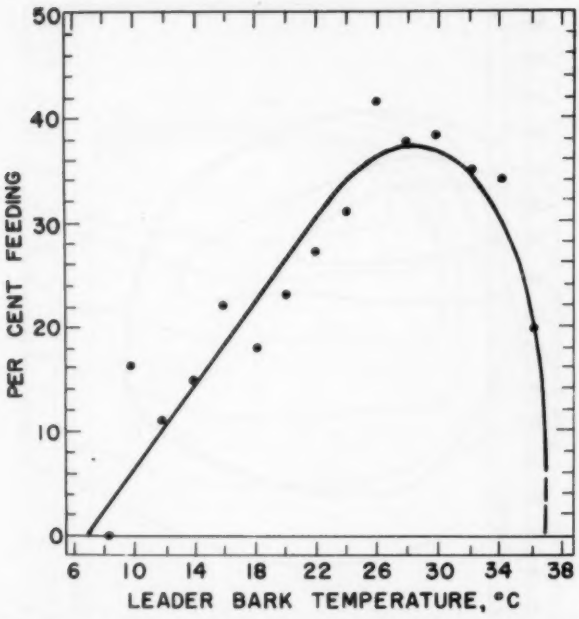

Fig. 8. The effect of white pine leader bark temperature on the frequency of feeding of adults of the autumn population of *P. strobi*: second degree polynomial fitted.

such as relative humidity and wind have little effect on the amount of feeding of the larvae. Temperature proved to be the most important of the physical factors affecting the rate of feeding of the larvae.

The field studies included inspection of a number of attacked white pine leaders for the purpose of recording the amount of movement of the enclosed larval populations. The total movement in all the leaders inspected was indexed in an attempt to eliminate the effect of variability resulting from differences in larval mortality, parasitism, and size. The method used to bring the totals to a comparable basis is shown in the following formula:

$$\text{Feeding index: } \frac{\text{(total movement)}\quad\text{(total number of trees observed)}.}{\text{number of trees showing movement}}$$

The change in feeding index was then determined. This represented the difference between two consecutive readings over a two-day interval, brought to a comparable basis with the formula above. As no detectable feeding by the larvae occurred at night, subsequent analysis involved determining the relation between the change in feeding index and the change in two-day mean temperature, calculated from records obtained between 0800 and 2000 hrs.

These studies were carried out during consecutive years. Comparison of the line slopes and mean square values, calculated from regression analysis of larval feeding index on ambient air temperature and bark temperature of the leader, revealed that the rate of feeding of the larvae of different generations was influenced similarly by temperature. Therefore, the records, based on observations of 69 infested leaders during the first year and 99 infested leaders during the second year, were combined and regression analysis of feeding index and mean air temperatures change gave a highly significant b value of 8.336. For each change

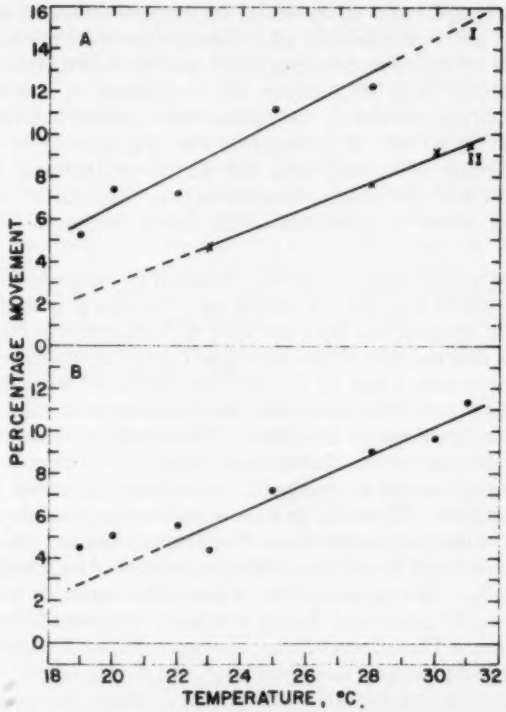

Fig. 9. The effect of white pine leader bark temperature on the movement of *P. strobi* larval populations down white pine leaders: A_I, A_{II}, amount of movement during the third and fourth days and 25th and 26th days of development, respectively. expressed as a percentage of the season's total; B, percentage movement of larval populations irrespective of age.

of 1°C, over a range of mean two-day air temperatures, 17.1 to 29.7°C, the average change in feeding index during a two-day period was 8.336 ± 1.52. Similarly, regression analysis of feeding index change on mean bark temperature change gave a highly significant b value of 6.547. For each 1°C change in temperature over a range of two-day mean bark temperatures of 18.5 to 31.8°C, the average change in the feeding index was 6.547 ± 1.19 cm.

The foregoing results show that temperature closely governs the rate of feeding and, hence, development of larval populations within infested white pine leaders. Additional analysis indicated variations in the temperature-feeding relations of the larvae that are directly related to the age of the individual populations in each leader. Observations showed that larval populations of various age groups were active in the field at the same time. Consequently, by measuring the amount of movement down individual leaders at two-day intervals, until larval feeding ceased, a series of comparable two-day readings of a common age group were obtained ranging over a temperature regime extending from 19 to 31°C. For comparison purposes, the distance the larvae moved down the leaders every two days was expressed as a percentage of the season's total. Bark temperatures were expressed as a two-day mean, obtained from measurements made at two-hour intervals between 0800 and 2000 hrs. Fig. 9A expresses the

influence of bark temperature of the leader on the percentage of the total amount of movement by larval populations in 37 leaders during their third and fourth days (line I) and by larval populations in 27 leaders during their 25th and 26th days of development (line II). These lines represent the outer limits of the observed differences in amount of movement that occurred during the developmental period of the larvae. It is apparent that the amount of movement, and therefore the feeding of young and old larval populations, increase as the temperature of the bark increases. In addition, the lines show that young larval populations move more quickly than older larvae within similar temperature ranges.

The effect of temperature on the movement of larval populations irrespective of their age is shown in Fig. 9B. A sample of 37 leaders was used and the results grouped into bark temperature intervals of 1°C, between the range 19 to 31°C. The figure shows that the rate of movement of the larvae continues to be directly governed by temperature when all the data are combined irrespective of the age of the populations. It will be seen that this line falls between lines I and II of Fig. 9A and that it lies closer to the latter. The similarity between the effect of temperature on the rate of development of larvae of all ages and of the older larvae alone indicates that major changes in population size occur during the early period of development. There is, in fact, considerable mortality among young larvae that reduces the population soon after feeding begins. It should be mentioned that the calculated line in Fig. 9B extends over a bark temperature range of 22 to 31°C only. The points at the 19 and 20°C intervals were not used, as these temperatures did not occur during the latter portion of the developmental season of the larvae. The effects of the differences in temperature level to which the larvae are subjected will be discussed later, but it may be mentioned here that they are important for the ultimate survival of individuals comprising the population within each leader.

Discussion

The results of this investigation indicate quite clearly that weather exerts considerable influence on weevil activity and development. In its natural habitat, open growing young stands of white pine, the insect is well adjusted to the environment, so that it seldom experiences the violent annual fluctuations in numbers common to populations of many other forest insects. Indeed, the very nature of the habitat serves to modify its climate so that the insects are seldom required to contend with extreme diurnal fluctuations of the kind occurring in xeric habitats (2). Although adverse weather conditions ranging above and below the upper limits tolerated by the adults do occur occasionally, behaviour patterns of definite survival value carry them to sites where conditions are more moderate (9). As might be expected, adverse weather conditions prolong weevil development and, if they persisted over long periods, they might be the cause of significant mortality in weevil populations. However, the adult weevil is capable of remaining active over a relatively wide range of climatic conditions, so that prolonged periods of weather adverse enough to result in death by starvation seldom occur. Individuals, therefore, are not apt to starve, though they may not be able to oviposit.

The most critical period in the development of *P. strobi* occurs during the spring and early summer. The quantitative approach has shown that temperature, solar radiation (reflected in bark temperature), and atmospheric moisture influence weevil activity and development. However, accurate predictions of activity cannot be made on the basis of the effects of individual factors

alone, as multiple factor analysis (cf., Figs. 6 and 7) have shown. Inadequate assessment of temperature-insect activity relations have often stemmed from failure to consider the humidity factor within the framework of governing elements. Pierce (5) was one of the first to show conclusively that definite changes in response occur outside particular combinations of temperature and humidity. The technique has since been used on numerous occasions and with good results (3,7), but in most instances it has been used to express the results of controlled laboratory studies. It is apparent, however, that the results of field studies, designed to obtain quantitative records on insect activity and development, may be effectively expressed in this way. For example, it has been shown here that humidity has considerable influence on adults, especially near the optimum temperatures for their activities, even though temperature has a more powerful general effect. In this respect, it is suggested that the rate of water loss at optimal temperatures is of primary importance to the insect's ability to remain at feeding and oviposition sites.

Autumn adults of the white pine weevil respond to temperature and light, at least initially, in essentially the same manner as spring adults (9). That is, they at times may be forced by extreme temperatures to vacate exposed sites within the habitat. Here, however, behavioural differences in the two populations of adults become evident. Spring adults begin feeding again only after they have returned to the leading shoot as conditions there moderate. Autumn adults, on the other hand, may continue to feed, after vacating exposed sites, on the older growth in more shaded sites, and are consequently not so strongly limited in feeding activity by temperature extremes.

Although the incubation period of the eggs varies to some extent with fluctuations in the microclimate (4,6), hatching success is less influenced by such fluctuations. However, successful establishment and development of the hatched larvae is strongly influenced by temperature. One of the interesting characteristics of the relation is that young larvae appear to feed more rapidly than older larvae within similar temperature ranges. There are two reasons for this. First, the amount of food available per unit length along an expanding or cylindrically-shaped leader varies in relation to the distance from the top of the leader. Although this difference is not great, the smaller amount at the top is available at a time when the greatest number of larvae are still alive to consume it. Therefore, their rate of travel is faster. Second, and more important, there is a marked difference in the number of larvae present in the two age-groups. Observations have shown that mortality of the larvae during development amounts to about 90 per cent[2]. The temperature-movement relations shown in Fig. 9 indicate that a high percentage of this mortality occurs during the early stages of development. This might be expected since it is this period of maximum competition and of relatively lower temperatures that slows movement and permits pitch-drowning.

It should be pointed out that temperature during larval growth is not the only factor influencing the developmental success of *P. strobi* larvae. The restriction of the adults to the leading shoot for oviposition purposes is a factor affecting survival of the following generation (8). Sufficient eggs must be deposited in a localized area of the main stem to permit hatching larvae to aggregate quickly into a common feeding group. Failure of the larvae to form and maintain a feeding ring results in high mortality. On the other hand, heavy deposition of

[2]Discussed in author's thesis, "A biological study of the white pine weevil, *Pissodes strobi* Peck, with special reference to the effect of physical factors on its activity and behaviour. Ph.D. Thesis, Macdonald College, McGill University, 1957. Weevil survival will be discussed in greater detail in a later paper.

eggs in a localized area may result in too many larvae per feeding group and competition for food may cause excessive mortality. A happy medium must be reached for the populations to survive at a significant level. Since temperature strongly affects adult oviposition behaviour, this effect as well as the effect of temperature on larval survival *per se* must be taken into account when population fluctuations of the insect are considered.

Although this paper presents evidence that *P. strobi* is well adjusted to the envrionmental conditions within open stands of white pine, there is considerable evidence that the insect is unable to adapt readily to the climate of many shaded stands (1). Therefore, the criterion for the establishment of weevil-free stands of white pine may be found in the limitations that weather imposes on weevil behaviour and survival. This aspect of the problem will form the text of a separate paper.

Conclusions

1. Maximum activity of adults of the spring populations of *P. strobi* occurs on relatively clear, warm days during which bark temperatures are elevated to between 26 and 31°C and relative humidities are maintained at low levels. At lower temperatures, the amount of activity decreases, but remains relatively constant over the greater part of the normal range of relative humidity. At bark temperatures above the optimum level, the amount of activity drops rapidly, and is zero at bark temperatures of 35°C and above. The lower limit of the bark temperature-activity range of the insect is 8°C.

2. Of the classified types of activity, oviposition occurs within the narrowest limits of temperature and moisture. Maximum oviposition occurs at leader bark temperatures of 25 to 29°C in conjunction with relative humidities of 20 to 55 per cent. At lower temperatures and higher humidities however, the amount of oviposition is reduced much more sharply than are feeding and copulation. Consequently, considerable feeding may occur during weather not conducive to oviposition.

3. During the autumn, no well defined pattern of feeding occurs, but the adults prefer the leader and exposed parts of the laterals of the upper three whorls of the trees when the weather permits feeding there. The amount of feeding of the adults is influenced chiefly by temperature and the insects are less affected by changes in atmospheric moisture and solar radiation. This is due to the fact that they may continue feeding in shaded points of the habitat where the temperatures are not extreme.

4. The rate of feeding of the larvae is related to the temperature of the bark. At higher temperatures the insects consume more food and hence move down the stems more rapidly. Observations have shown that survival of individual populations of *P. strobi* larvae is dependent not only upon temperature, but also upon their size and their distribution within individual stems.

Acknowledgments

I wish to express my thanks to Professor E. M. DuPorte, Department of Entomology, Macdonald College, McGill University, and to R. M. Belyea, G. W. Green, and other members of the Forest Insect Laboratory, Sault Ste. Marie, Ontario, for their suggestions and criticisms. I am grateful also to W. G. Wellington, Head, Bioclimatology Section, Forest Biology Laboratory, Victoria, B.C., for his assistance during the initial phases of this investigation and in the preparation of the manuscript.

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Control of Black Fly Larvae (Diptera: Simuliidae) in the Forests of Eastern Canada by Aircraft Spraying[1]

By A. S. West[2], A. W. A. Brown[3], and D. G. Peterson[4]

Introduction

The results reported in this paper are part of a study of the biology and control of black flies in the forests of Eastern Canada conducted on the north shore of the St. Lawrence River, near Baie Comeau, Quebec, during 1954, 1955, and 1956. Reference to this study is made in a review by Peterson and Wolfe (1958). The identification and biology of the black flies of this region has been reported on by Wolfe and Peterson (1959) who also describe the topography of the region. The important feature of this rugged area is an abundance of fast-flowing streams which provide highly suitable environments for the development of black-fly populations.

The successful control of black flies by aerial application of larvicides was reported by Travis *et al.* (1951), Collins *et al.* (1952) and Jamnback and Collins (1955) as the result of studies conducted in the Adirondack region of New York State. The application of DDT to streams by means of a flight plan involving flight lines at one-quarter mile intervals is being adopted for increasingly greater areas of the Adirondack region each year.

In 1954, near Baie Comeau, an experiment was conducted to determine whether the aerial application of DDT on the periphery of a drainage basin would result in sufficient DDT being deposited in, or washed into the streams

[1]The results reported herein were obtained by the former Veterinary and Medical Entomology Unit, Entomology Division, Department of Agriculture, Ottawa, Canada, in a program of studies carried out on behalf of the Pulp and Paper Association of Canada and in co-operation with the Pulp and Paper Research Institute of Canada, Montreal, Quebec.

[2]Department of Biology, Queen's University, Kingston, Ontario; in the seasonal employ of the Canada Department of Agriculture, as Entomologist, when this work was performed.

[3]Department of Zoology, University of Western Ontario, London, Ontario; in the seasonal employ of the Canada Department of Agriculture, as Entomologist, when this work was performed.

[4]Entomology Laboratory, Canada Department of Agriculture, P.O. Box 248, Guelph, Ontario.

within the basin to control the black-fly larvae and reduce the subsequent infestation of adult flies. The ¼-mi. interval strip plan of aircraft spraying employed by Collins *et al.* (1952) was assessed in 1955 on two plots, and, in 1956, an entire river drainage was sprayed in this manner.

Methods and Results

1954 Season

The Georges Tremblay River drainage basin with a total area of 40 sq. mi. and a periphery of 42 mi., was treated with DDT between May 28 and June 1. The basin contains 134 mi. of streams large enough to be mapped, including 17.5 mi. of the Georges Tremblay River itself. A total of 1,088 imp. gal. of an 11 per cent (wt./vol.) solution of DDT in fuel oil was applied along a flight line approximately 200 yd. inside the periphery of the drainage. The aircraft was a DHC-2 Beaver fitted with a rotary brush spray assembly. Brown (1952) has described the rotary brush unit.

Larval populations were assessed from May 20 to July 6 at 32 stations within the treated drainage basin by three observers simultaneously counting for a 5-min. period all larvae to be found on rocks, sticks or debris in the streams. Similar assessments were made at 31 stations in an adjacent untreated drainage area on the English River.

After the application, no reduction was shown at seven of the 32 stations; these streams were found to have their source well within the periphery of the area, and no less than 42 per cent of the stream mileage of the area was in this category. At the 12 stations on streams originating at the periphery of the watershed, a 98 per cent reduction became apparent by June 3. At the 13 stations on the main Georges Tremblay river, the larval population disappeared completely by June 14. This effect was evidently due to drastic alterations in the river level during the log drive, since almost complete disappearance occurred in the English River also after the drive. Populations on the peripheral streams and main Georges Tremblay River had recovered and surpassed pre-spray levels by June 28.

Adult black flies appeared on June 13, and eight daily population assessments were made between June 15 and July 3, at 18 points in the Georges Tremblay River drainage basin and simultaneously at 12 points in the control English River drainage basin, by two teams of three observers. Sitting with an 18-in. square of dark blue flannel placed against the trousers, they counted the number of landings in 1 min. after an initial wait of 2 mins. The average population count in the treated area was 49.5, as compared with 47.4 in the control area. Since single very large counts could distort the arithmetic average, logarithmic averages were taken and showed 27.9 for the Georges Tremblay River area as against 39.6 for the English River area. It is evident that the peripheral DDT treatment did not significantly reduce the adult infestation.

1955 Season

Two portions of the Wood River drainage basin, north of Baie Comeau, were sprayed using the ¼-mi. interval strip plan. Plot A, 15 sq. mi. in area, was scheduled to receive a dosage of 0.02 lb. of DDT/area-acre, by an application at a rate of 3.2 lb. of DDT/flight mile. Plot B, 11 sq. mi. in area, was to be treated at 0.1 lb. of DDT/area-acre by an application at a rate of 16 lb. of DDT/flight mile. A check area lay principally to the south of Plot B. Much of the area of the experimental plots had been, or was being cut-over, and a number of the smaller streams were more or less completely covered with brush or by corduroy roads for much of their courses.

The establishment of larval sampling stations was limited by accessibility of streams and the necessity of extensive travel on foot. Seventeen stations were located in Plot A to give an assessment of larval populations in eight streams or parts of these streams. Twenty-six stations were established in plot B to provide an assessment of eight streams or parts of these streams. In addition, single visits were made to six less accessible streams in plot A and eight such streams in plot B during mid-June, approximately one week after the sprays were applied.

Twenty-two stations were established in the check-area to sample 11 streams. The majority of the stations were established and two or three larval counts were made prior to the spray applications. In both spray plots, and in the check area, assessment points were established to sample a range of large and small streams. Larvae were found at all stations at the time of their establishment, even though sometimes no larvae were found subsequently. Several stations were established in the Wood River and its major tributaries after the spray period. At the time of spraying, these streams were being used for pulpwood drives and few if any larvae were present.

Larval population estimates were obtained by the use of the metal white-painted cones described by Wolfe and Peterson (1959). Cones were positioned in pairs at each station. Counts obtained on the two cones of a pair frequently differed, indicating the importance of microenvironmental differences. Trends were, however, consistent. When the entire cone was covered with larvae and pupae, a wedge was counted and this count used to estimate the total. With the aid of hand tallies, counts of up to 1,500 larvae could be made without undue difficulty. It was found that cones were not particularly suitable for pupation, and pupal counts were of little value other than to give an indication of seasonal development. Many cones were moved one or more times during the season as necessitated by lowering water levels. In mid-June all cones were cleaned to reduce the complexity created by overlapping broods. The population records obtained show trends rather than having any absolute value.

At least 10 species of black flies were present in the study areas. However, species of the *Prosimulium* (*Prosimulium*) *hirtipes* Fries and *Simulium* (*Simulium*) *venustum* Say complexes were the only ones present in large numbers. Unfortunately, because of unavoidable delays in readying the aircraft, an estimated 50 per cent of the overwintering larvae of the *P. hirtipes* complex and significant proportions of the first brood of the *S. venustum* complex, i.e., from overwintered eggs, had pupated at the time of spraying on June 8 and 9.

The spray was applied to plot A during the early morning hours of June 8 and to plot B during the evening hours of June 8 and the early morning hours of June 9. All spraying was done with a DHC-2 Beaver fitted with a rotary brush emission apparatus and when wind speeds were less than 5 m.p.h. and upward convection was negligible. Flight lines, at one-quarter mile intervals, were plotted on aerial photographs and were followed by aid of an observer to assist the pilot. Because of the roughness of the terrain, with many precipitous slopes, flight altitude varied from 200 to 600 ft. during spraying. It is recognized that fluctuations in altitude influenced the swath width.

For plot A, a total of 220 gal. of an 11 per cent (wt./vol.) solution of technical DDT in fuel oil was emitted at an average rate of 4 lb. DDT per flight mile. This solution was prepared by diluting one part of JP-30 concentrate (30 per cent DDT on a wt./wt. basis, having a specific gravity of 1.0975 and therefore containing 3.3 pounds of DDT per imp. gal.) with two parts of diesel oil which was used, of necessity, in place of furnace oil. For plot B, a total of 514 imp. gal.

of a 16.5 per cent solution (wt./vol.) was used at an average rate of 18.3 lbs. DDT per flight mile. Two flights were required for plot A and five for plot B.

A study of the cone records for individual larval assessment stations showed that rapid apparent fluctuations in populations were characteristic of both spray areas and the check area. For this reason, the effect of the spray was assessed by comparing averages of the last two pre-spray counts with averages of the first two post-spray counts for the single cones of each pair. One set of counts for each station is given in Table I. It is emphasized that the resulting figures, as the counts themselves, have no absolute meaning and cannot be used as a basis for calculation of percentage reduction of larvae. They do, however, furnish an adequate demonstration of the effect of the sprays.

In the check area, larval populations remained relatively stable during the spray period. Differences between pre- and post-spray counts were typical of fluctuations observed throughout the season. An exception is check station 3C which was by error located at the southern edge of plot B. Larval populations were wiped out by the spraying. Larvae at Station 3B, one-tenth of a mile upstream, were not affected by the spray. Commonly during the last half of June, there was a decline in larval populations, apparently associated with lowering of water levels.

Stations established on the Wood River and Phillip Creek after the spray dates showed that the streams used for the log drive supported few if any larvae during the drive but were the large producers during the latter half of the season, when many of the smaller streams had partially or completely dried up.

Direct comparisons cannot be made between check and spray areas, but it is clear that there was no indication of any general decline in larval populations in the check area at or about the time of spraying.

Table I shows that in plot A, larvae were nearly or completely eliminated by the spray in streams 5, 6, 7, and 8. In stream 4, a section of the Wood River, populations were extremely low from the start until later in the season. It is also evident that in streams 1, 2, and 3, the spray had no effect. All three of these streams lie near the eastern boundary of plot A. Streams 1 and 3 ran more or less parallel to and approximately midway between the first two flight lines. Apparently, because of their position, these streams did not receive any spray. Stream 2 occurs at the very edge of plot A and station 2A practically coincided with the start of the first flight line which was flown north from the limit road. It seems probable that pilot error in turning on the spray may have accounted for the lack of control.

During mid-June, when single visits were paid to more inaccessible streams, observations supported the evidence furnished by the sampling stations. In fast-flowing streams which might be expected to support larval populations, and which could be assumed to have been crossed by one or more flight lines, no larvae were found. A slow, deep stream, overgrown with alders, crossed by several flight lines, supported small populations. A combination of protective cover and slow water might account for the failure of the spray to destroy the larvae. Empty pupal cases were abundant in a number of streams and adult black fly activity was at a high level. The conclusion is that a dosage of 3.7 lbs. of DDT per flight mile will give satisfactory control providing streams are exposed, and are crossed by one or more flight lines.

In plot B, larvae were greatly reduced in numbers or eliminated in all streams examined, by the emission of 16.6 lbs. of DDT per flight mile (Table I). Stream 3 provided an interesting record at station 3A. Larvae were nearly eliminated for

TABLE I

Populations of black-fly larvae and pupae in two plots, A and B, treated from the air with DDT at 4 and 18.3 lb. DDT per flight mile respectively, and in an untreated area, Wood River drainage basin, near Baie Comeau, Quebec, 1955.

Plot A			Plot B			Check Plot		
Stream and Station*	No. of larvae and pupae†		Stream and Station*	No. of larvae and pupae†		Stream and Station*	No. of larvae and pupae†	
	Pre-spray	Post-spray		Pre-spray	Post-spray		Pre-spray	Post-spray
1A	850^{4}	1550	1A	4	0	1A	950^{950}	550^{800}
1B	403	1452	2A	97	2	2A	2250^{350}	3400^{100}
1C	168	65	2B	129	12^{2}	2B	377	1050
1D	0	0	2C	0	0	3A	1360	865^{3}
2A	391	1243	3A	645	21^{3}	3B	50	48
3A	155	8	3B	1	3^{1}	3C‡	59	0
3B	237	1150	3C	88	0	4A	2	17
4A	0	0	3D	16	0	4B	1	1
4B	2	0	3E	0	1	4C	13	33
5A	142	0^{2}	3F	2	0	4D	1	32
5B	395	0	4A	0	0	4E	0	5
5C	13	1	5A	549^{1}	0	4F	5	6
6A	82	0	6A	221	0	5A	3	1
7A	51	0	6B	19	0	6A	14	68
7B	29	0	7A	26	0	6B	1	0
8A	911	0^{2}	7B	3	0	7A	2	0
8B	1019	1^{5}				8A	0	0
						9A	0	0
						10A	0	0
						11A	0	1

*Number denotes stream, letter the station (see Fig. 1).
†Average of last two pre-spray and first two post-spray counts. The numbers of pupae are shown by raised script.
‡Located, by error, at the edge of Plot B.

the immediate post-spray period. However, on the third day following spraying the numbers of larvae recorded increased and an abundant infestation was present until the first part of July, when a drop in water level made the stream no longer suitable for black fly production. Upstream from 3A there was an almost solid cover of logs over the stream. It appears that the upper reaches of this stream did not receive DDT directly and that larvae recorded at 3A subsequent to the spray were ones which had moved down from upstream. This was the only stream in plot B in which control was not satisfactory. Single examinations of a number of less accessible streams substantiated the evidence provided by the cone counts. It is not concluded that the heavier dosage applied to plot B produced any more effective control, but rather that the topography of plot B made possible a flight plan which afforded greater chance of effective treatment of all streams.

Because of the proportion of larvae which had pupated before the spray applications, no attempt was made to assess the effect of the spraying on adult populations.

1956 Season

The major changes in the 1956 program, as compared with that of 1955, were: (1) use of commercial aircraft fitted with a boom-type spray apparatus; (2) spraying of an entire river drainage; (3) spraying in advance of pupation of the overwintering brood; and, (4) follow-up ground treatment of pulpwood drive streams.

The entire Wood River drainage on the Baie Comeau limits of the Quebec North Shore Paper Company was selected for treatment. This drainage consists of an irregularly shaped area of approximately 64.5 sq. mi. The topography is rough with elevations ranging from 400 to 1,600 ft. and with a number of almost vertical cliffs. Except in the southwest portion of the drainage, the area is characterized by numerous lakes and streams. A number of branches of the Wood River system were used for pulpwood drives.

Untreated check streams east and south of the Wood River drainage were selected with regard to accessibility and similarity to streams within the spray area.

The spray plan was essentially the same as in 1955. Parallel flight lines were mapped at one-quarter mile intervals, and the drainage was divided into seven areas on the basis of recognizable topographic features. A contour flight plan was adopted for one area which was exceedingly rugged. Depending on its length and course, a stream was crossed by one to several flight lines.

Two Stearman biplanes, each fitted with a boom-spray rig with 22 spray-cone nozzles under positive pressure and a 125-gal. tank, were made available under contract. The spray plan called for dispersal of a 16.5 per cent solution (wt./vol.) of DDT in fuel oil, at a rate of 16.0 pounds of DDT per flight mile. Since the Stearman has no place for an observer, adherence to planned flight pattern was entirely dependent on the pilot.

Sampling stations were established at 94 locations on 65 streams within the spray area and at 24 check area sites. Paired, white-painted metal cones were used as in 1955. Because of the area involved and inaccessibility, most stations were visited only at weekly or greater intervals. Not all stations were established prior to spraying, since some areas were still inaccessible because of snow. No stations were established on the drive streams until the drive had been completed. Ten species of black flies were determined from pupal specimens. The *S. venustum* complex was most abundant and the *P. hirtipes* complex second in

numbers. This relative abundance was substantiated by identification of representative collections of adults.

Flying was done from the Baie Comeau airport, approximately 33 miles from the centre of the spray area. The maximum flight distance was about 50 miles. Mixing of the spray and loading of the aircraft was done with a gasoline-operated pump capable of filling the 125-gallon insecticide tank of a Stearman in about four minutes. A 2,000-gallon tank was available for mixing the spray. The 16.5 per cent DDT solution (wt./vol.) was prepared as in 1955 except that furnace oil was used as a diluent. An emulsifier, Triton X-100, was added in a concentration of one per cent as a possible aid to the leaching of the larvicide into the streams.

Spraying was begun on the morning of May 29, continued in the evening, the morning and evening of the 30th, the evening of the 31st, and completed during the evening of the second of June. All spraying was done when wind speeds were less than 5 m.p.h. and upward convection negligible. Seventeen and one-half loads, or approximately 2,200 gal. of insecticide were used. Delays were occasioned by leaking tanks and unfavourable weather. If two planes had been available at all times, the operation could have been completed in two days.

Faulty calibration of insecticide delivery rates which could only be partially corrected, leakages and plugged nozzles resulting from disintegration of a lining of the mixing tank contributed to variations in delivery rates which ranged from 10.6 to 29.9 pounds of DDT per flight mile. Although this lack of uniformity is undesirable, it had no obvious effect on the degree of control achieved. Even with a uniform delivery rate, actual deposition would vary according to changes in swath width resulting from flight altitude variations when flying over rough country. The present variations in delivery rate were randomly distributed and for practical purposes it was calculated that deposition of DDT for the entire area averaged 14.1 lbs. per flight mile.

As compared with the dry summer of 1955, conditions following spraying in 1956 were particularly favourable for increasing the effectiveness of the spray. A rainfall totalling 0.35 ins. on the first and second of June and 0.31 in. on the fifth may have been extremely beneficial.

Earlier studies had shown that very few larvae develop in streams used for driving pulpwood until after the drive is completed. In 1956, larval sampling stations were established on all accessible drive streams after the drive was completed. When observations showed that larval populations were starting to develop, the streams were hand-treated by the standard procedure (Can. Dept. Agriculture Pub. 940, 1955) involving the application of one part of DDT per 10,000,000 parts of water, the DDT being introduced as a 10 per cent oil solution over a 15-minute period.

Establishment of cone stations was begun on May 15, at which time only larvae of the *P. hirtipes* complex were present in any numbers. During the last week of May, hatching of eggs of the *S. venustum* complex was recorded at several lake outlets. When spraying was begun, on May 29, larvae of the *S. venustum* complex were still very small in most streams and had moved downstream from oviposition sites in only small numbers. Normally the best degree of control might be expected by spraying at a time when larvae of the *S. venustum* complex had become well-distributed downstream. Thus it is believed that the 1956 operation was not conducted at the most opportune time, in spite of which excellent results were obtained.

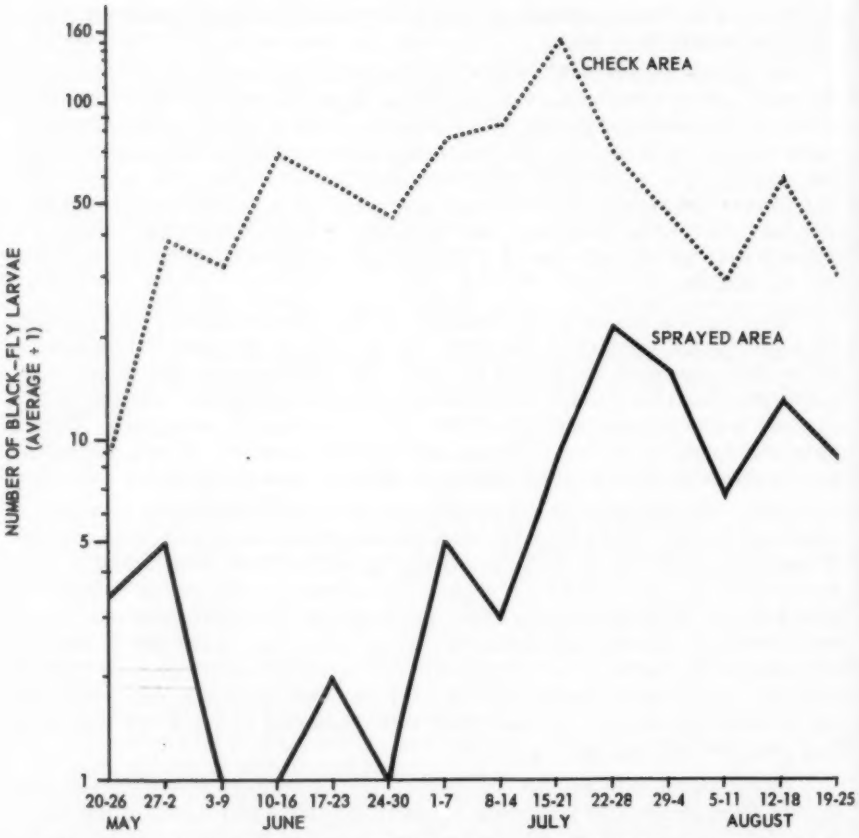

Fig. 1. The seasonal distribution of black-fly larvae, determined by cone counts, in the Wood River drainage basin that was treated by an aerial application of DDT between May 29 and June 2, and in untreated streams outside the basin, in Baie Comeau area, Quebec, 1956.

Since large populations were not attaching to cones before the spray period, control could not be demonstrated in terms of disappearance of larvae. Rather, control was shown by the failure of an expected build-up of larval populations to materialize in favourable spray-area streams as compared with a normal increase in populations in check streams (Fig. 1). Again, it is emphasized that the figures have no absolute meaning and that only trends in population fluctuations have any real meaning. The number of samples varied from week to week since it was not possible to visit all stations during any one-week period, and since some stations were not established until after the spray period. Means were calculated by averaging recorded populations for a pair of cones and taking the mean of these averages for all stations visited during a particular week. An inspection of records for individual stations supports the indications of population trends shown in Fig. 1.

In the spray area, larvae were eliminated or, where they did not occur prior to spraying, did not appear during the immediate post-spray period, in all but one small stream of a total of 65 streams examined. All these streams were

TABLE II

The effect of the control of black-fly larvae, by an aerial application of DDT, on the subsequent adult black-fly activity, Wood River drainage basin, near Baie Comeau, Quebec, 1956.

Date	Landing rates*			
	Mean		Maximum	
	Sprayed area	Check area	Sprayed area	Check area
June 14	2.8	10.3	14.0	31.0
June 21	5.8	97.0	58.5	510.0
June 28	11.3	60.7	50.0	190.5
July 5	17.0	42.6	62.5	281.0
July 12	19.5	35.3	93.5	103.5
July 20**	5.9	24.7	15.0	45.5
July 27**	6.6	14.5	15.5	47.5
July 31	11.0	21.3	32.5	100.5
Aug. 8	1.7	8.8	7.0	48.0
Aug. 17**	2.5	3.0	3.5	14.5

*Determined at 15 points inside the sprayed area, and the same number outside, by two, simultaneous 1-min. counts of the number of flies landing on a blue cloth.
**All stations were not visited due to unfavourable weather.

judged to be black-fly producers under normal conditions. As opposed to this, most check streams showed a development of larval populations in degree according to the suitability of the particular stream.

Scattered pupae of the *P. hirtipes* complex were recorded in the spray area during the week following spraying; these individuals were assumed to have pupated prior to spraying. *S. venustum* complex pupae were not found until July 10 and then only in small numbers. Figure 2 shows that larval populations remained very low and significant numbers did not appear until after the middle of July. Through the season larval populations remained at lower levels within the spray area than outside, although the fluctuations in populations after the middle of July were generally similar in sprayed and unsprayed streams.

Fifteen sites within the spray area and a similar number outside were selected for adult landing-rate count stations. Counts were started soon after the first adults appeared and were continued at weekly intervals during the season (Table II). The counting technique was the same as used in 1954 by West and Peterson (1960). When possible, two crews were used to complete all counts between the hours of 2 and 5 on one afternoon. When only one counting crew was available, counts were completed on two successive afternoons with approximately equal numbers of spray-area and check-area stations visited on each of the two afternoons. Stations were always visited in a definite order. The average of two simultaneous counts for each station was taken and the mean of these averages for all spray-area or check-area stations calculated for each day's observations. Since a few high landing rates would obviously influence the means, the maximum of two simultaneous counts for each week was also determined. Fluctuations from week to week do not necessarily have any meaning, since the weather on any particular day was more or less favourable for adult activity as compared with another day.

The data in Table II show that landing rates were consistently lower in the spray area as compared with outside. It is of interest to note that the highest mean and highest average of any two simultaneous counts in the spray area was

recorded on July 12, which was *before* any emergence of adults occurred in the spray area. It is apparent that these adults had migrated into the spray area from outside the Wood River drainage. The number of stations and number of counts taken were too few to permit an examination for evidence of correlation between landing rates and distances from particular stations to the periphery of the drainage. It was obvious to experienced observers that adult populations were less at all times within the sprayed area.

Discussion

The aerial spraying in 1954 of the periphery of a drainage basin for the control of black-fly larvae was not successful since only one-half of the streams in the basin had their sources at or near the periphery and received sufficient DDT to affect the larvae. The subsequent adult infestation was not noticeably reduced, since large numbers of flies emerged from streams unaffected by the treatment. Later in the season, subsequent generations emerged even from the treated streams.

The effectiveness of aerial spraying of DDT at ¼-mi. intervals for the control of black-fly larvae was demonstrated by the experiments conducted in 1955 and 1956. In 1955, a few streams within one of the two plots were not treated due to their location between spray swaths or to pilot error. When an entire drainage basin was treated in 1956, larvae were found in only one small stream of those examined. It was concluded that, in 1956, essentially no black-fly adults emerged from streams within the sprayed area until the middle of July. In contrast, emergence of adults in numbers began in unsprayed areas about June 10 and peak adult populations were recorded before the first of July.

Acknowledgments

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Survival of Unfed First-Instar Grasshoppers[1]

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During some investigations on grasshoppers it became necessary to know how long they would survive without food or water after hatching. The literature contains only scanty observations. Washburn (1911) reported that grasshoppers "freshly hatched, can live from four to five days without food". Langford (1930) showed that 30 per cent of *Melanoplus femur-rubrum* (DeG.) and *M. differentialis* (Thos.) (adults?) survived for two days at 95° F. without food and 100 per cent survived for two days at 69° F. At 38° F. 40 per cent survived for 13 days. Telenga (1930) kept first-instar *Schistocerca gregaria* Forsk. in outdoor cages without food and water where they survived only two days. Bodenheimer (1929) found that the average life of newly hatched *S. gregaria* in outdoor cages without food at ± 15° C. was 3.6 days, with a maximum of nine days, and that later instars that were starved lived longer at higher humidities. Ludwig (1937) testing the effect of different relative humidities on survival showed that third-, fourth-, and fifth-instar *Chortophaga viridifasciata* (DeG.) survived starvation for 5.2 to 6.6 days at 25° C. at all relative humidities from 5 to 96 per cent.

To obtain accurate data on time of survival in relation to temperature, newly hatched nymphs of *Camnula pellucida* (Scudd.) and *M. bilituratus* (Walk.) were placed individually in cages in rooms where the temperature was controlled within ± 1° C. at 20, 25, and 30° C. Twenty nymphs of each species were used for each treatment. A control group of 20 nymphs of each species, similarly caged and maintained at each temperature, was fed on cut seedling wheat leaves. The cages were glass cylinders 1½ inches by 6 inches of a type previously described (Smith, 1959).

Survival of the starved grasshoppers is shown in Fig. 1. Both species reacted similarly, all were dead after four days at 30° C., five days at 25° C., and eight days at 20° C. This last temperature is near the minimum for activity. Survival in the control groups after eight days varied from 85 to 95 per cent except for *C. pellucida* at 20° C. where it declined to 53 per cent after eight days.

A considerable variation in time of initiation of feeding in the controls was noticeable. Feeding started as early as eight hours after hatching at 30° C. and as late as 48 hours after hatching at 20° C. Some grasshoppers never fed. The one *M. bilituratus* nymph that died in each of the 25 and 30° C. controls never ate. One *M. bilituratus* nymph in the 20° control went for six days without feeding and then died.

The duration of survival of starved grasshoppers has a bearing on cultural control practices. Grasshoppers hatching in fields where tillage has destroyed all green growth may die of starvation before they reach a source of food. Riegert *et al.* (1954) released 30,000 second-instar nymphs of *C. pellucida* at one site on bare soil. After eight days they had moved a maximum of 90 yards from the release point with an average advance of 66 yards. Even when the more mobile fifth-instar and adult *M. bilituratus* were released under similar circumstances, 60 per cent of them were still within 50 yards of the release point after seven days and only 10 per cent had travelled over 100 yards. There was no evidence of a directed movement toward food. Hence the great majority of grasshoppers that hatch at a distance of 75 yards or more from food will die of

[1]Contribution from the Entomology Section.

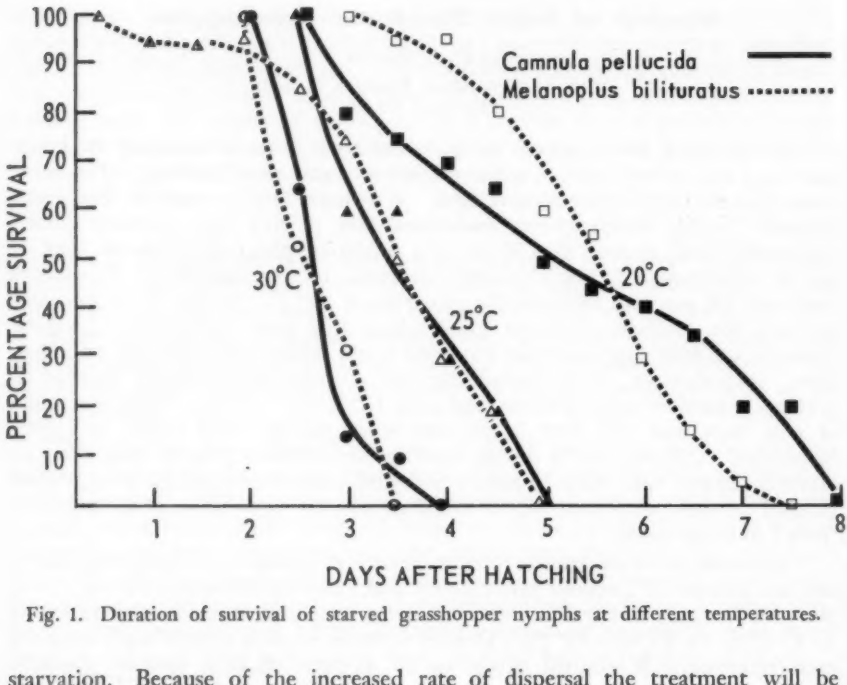

Fig. 1. Duration of survival of starved grasshopper nymphs at different temperatures.

starvation. Because of the increased rate of dispersal the treatment will be progressively less effective with later instars.

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Note on the Occurrence of Two Species of Thrips (Thysanoptera: Thripidae) on Low-bush Blueberry in New Brunswick and Nova Scotia[1]

By G. W. Wood

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Since 1947 a blueberry thrips, *Frankliniella vaccinii* Morgan, has been reported as a common pest of the low-bush blueberry in New Brunswick. In a previous note Wood (1956) described the injury caused by the thrips under the assumption that only one species was involved. During the summer of 1958, however, several specimens of thrips collected in Charlotte County, N.B. were sent, by request, to L. J. Stannard of the State Natural History Survey Division, Urbana, Illinois, who discovered two species, *F. vaccinii* and *Taeniothrips vaccinophilus* Hood, were included. This information was quite surprising and prompted further examination of specimens collected in this area prior to 1958. These specimens were examined by W. R. Richards, Entomology Research Institute, Ottawa, who reported that both species were present. Specimens collected between 1947 and 1951, however, were all *F. vaccinii*, those collected in 1951 were about 75 per cent *F. vaccinii*, and those collected since 1951 were mostly *T. vaccinophilus*. These records show that *T. vaccinophilus*, which appeared in or about 1951, has rapidly replaced *F. vaccinii* as the predominant species infesting blueberry in this area.

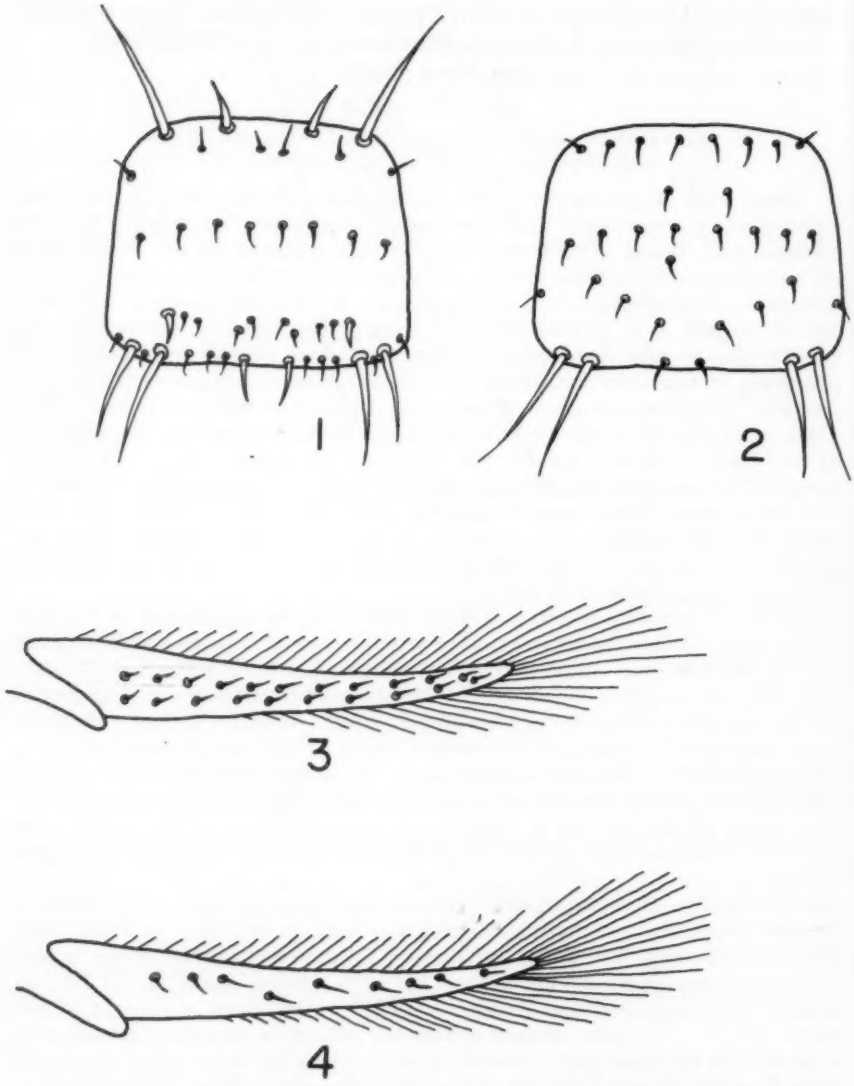
A survey was carried out in 1959 to determine the distribution of the two species in the various blueberry-growing areas of New Brunswick and in adjacent areas of Nova Scotia. In all fields sampled in Charlotte County, N.B., *T. vaccinophilus* was the predominant species. In the eastern and northern counties the two species were collected in approximately equal numbers. In two collections from Cumberland County, Nova Scotia, *F. vaccinii* was the predominant form, outnumbering the other species ten to one. These records suggest that *T. vaccinophilus* has moved into this area from the New England States, and that the distribution of the species is rapidly extending eastward. The species was originally described from collections on blueberry in New York State by Hood (1936).

The known life-histories of the two species are similar. Overwintered females emerge from the soil and attack the plant in late May or early June. They lay their eggs within the leaf tissue. There are two larval stages, a prepupa stage (non-quiescent) in each. The thrips become adults in late July or August. All stages are passed within leaf galls which form as a result of the thrips' attack. The galls of each species are similar, in fact both species may occur within the same gall. Shortly after reaching the adult stage the thrips leave the plant and move into the soil by late September. Males succumb during late fall or winter and only females emerge the following spring.

In the absence of other incidental species the following characters may be used to separate *F. vaccinii* and *T. vaccinophilus*.

1. Anterior angles of prothorax with spines as long as those on posterior angles (Fig. 1); fore wings with two rows of evenly spaced spines (Fig. 3) ..... *F. vaccinii*
2. Anterior angles of prothorax with spines much shorter than those on posterior angles (Fig. 2); fore wings with irregularly spaced spines (Fig. 4) ..... *T. vaccinophilus*

[1]Contribution No. 15, Research Station, Canada Department of Agriculture, Fredericton, New Brunswick



Figs. 1-4. 1, 2. Pronotum. Minor setae variable in number and position: 1, *Frankliniella vaccinii* Morgan; 2, *Taeniothrips vaccinophilus* Hood. 3, 4. Dorsal view of right fore wing: 3, *F. vaccinii;* 4, *T. vaccinophilus.*

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Notes on Life-History and Parasites of *Syngrapha epigaea* (Grt.) (Lepidoptera: Noctuidae)[1]

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It is perhaps because of their unimportance as insect pests that larvae of the genus *Syngrapha* have been so little studied. *Syngrapha epigaea* is no exception to this; but since it is one of the most common species of larvae found in commercial blueberry fields of eastern Canada, the following notes on its life-history and parasitism are here recorded.

Larvae were collected each spring from 1950 to 1957 by sweeping blueberry fields and all data given are based on insectary-reared specimens. One egg mass was obtained from a gravid female taken by light-trap. Records on parasitism do not include any species which parasitize the pupal stage.

Description of Egg and Larva

The egg is circular in outline and semicircular in profile with beaded dorsoventral striations. When laid it is pale yellow, but it becomes dark yellow before hatching. In confinement eggs were laid singly on the sides of a container rather than on blueberry foliage in the container.

The body colour of the first-instar larva is pale yellow and uniform throughout its length; there are no discernible body markings. The cervical and anal shields are the same colour as the body, and the head shield is pale yellow with prominent black ocelli. The body length is 2.1 mm. and the width 0.3 mm. The most prominent features of this instar are the long, black, filiform setae, and the black setigerous rings.

The second-instar larva appears similar to the first except that the colour has turned to a pale greenish-yellow. The body length is 5.5 mm. and the width 0.6 mm.

The third-instar larva is pale green with a narrow white subdorsal line and a thicker white spiracular line. Both lines extend from the anterior end of the thorax to the anus. The body length is 7.0 mm. and the width 0.9 mm. The head, cervical, and anal shields are the same colour as the body. The ventral surface is pale yellowish-green. The setae are less prominent than in the earlier instars.

In the fourth instar the body colour is light green, the length is 8.5 mm. and the width 1.1 mm. There is a narrow, broken, white subdorsal line, and a narrow white addorsal line, which begins on the abdominal segments and is not continuous to the anus. The white spiracular line is much thicker than the other lines.

The general body colour remains the same in the remaining instars. In the fifth instar the addorsal line is more prominent; it begins on the second thoracic segment and extends to the anus. The subdorsal line begins on the cervical shield and extends to the anus. Both lines are broken intersegmentally. The black setigerous rings are surrounded by a white patch. In the eighth (last) instar the dorsal blood vessel becomes visible mid dorsally as a dark green line. The head shield is light green with dark brown markings. Full grown larvae are about 22 mm. long and 4.5 mm. wide.

[1]Contribution No. 14, Research Station, Canada Department of Agriculture, Fredericton, New Brunswick.

Life-History and Habits

Larvae of *S. epigaea* are both diurnal and nocturnal feeders. They apparently prefer the blueberry as a host plant but will readily feed on the foliage of other plants which are commonly found in blueberry fields; this is particularly evident in late fall when the species feeds mainly on lambkill, *Kalmia angustifolia* L., after blueberry foliage has dropped. In other areas the species has been collected from *Myrica gale* L. (Ferguson, 1954) and juniper, trembling aspen, spiraea, larch, and saskatoon (McGuffin, 1954).

The larval stage begins in early September and feeding continues until early November. Larvae overwinter in the soil in the fourth or fifth instar and emerge during late April. They pass through eight instars. Head capsule measurements for each instar were as follows:

Instar	I	II	III	IV	V	VI	VII	VIII
No. measured	12	60	108	100	77	33	38	21
Range (mm.)	0.26–0.32	0.36–0.41	0.44–0.53	0.56–0.73	0.76–0.97	0.99–1.30	1.33–1.62	1.72–2.24
Mean (mm.)	0.30	0.38	0.50	0.65	0.85	1.12	1.46	2.03

Larvae cease feeding about the middle of June, and spin a cocoon on the blueberry foliage; pupation generally occurs within a week. The duration of the pupal period has varied from 16 to 38 days but usually lasted between three and four weeks; the adults emerge throughout July. As the moths are rarely attracted to light or baits, no information was obtained on the flight period. Only two moths were collected, one on August 10 and one on August 16; that of August 10 laid 45 eggs on August 12-13, so its seems that most of the eggs had been laid before the moth was caught. The duration of the egg stage was six to nine days when they were incubated at 70° F. A longer period would be expected under field conditions.

Parasitism

Twelve species of primary hymenopterous parasites were obtained from rearings of *S. epigaea*. Determinations were made by officers of the Entomology Research Institute, Ottawa, as follows: Braconidae, Dr. W. R. M. Mason; Ichneumonidae, Mr. G. S. Walley, Mr. C. D. Miller; Encyrtidae, Dr. O. Peck.

The percentage parasitism of larvae collected in the spring varied from 8.9 to 30.7 per cent, while parasitism of specimens collected in the fall varied from 9.8 to 12.3 per cent.

Braconidae

One specimen of *Meteorus vulgaris* (Cress.) was reared in 1957. It emerged from the host larva and pupated on May 21 and had a pupal duration of 20 days.

Larvae of *Apanteles longicornus* (Prov.) emerged from the host larvae and pupated June 17-July 29. The duration of the pupal period was about two weeks. *Apanteles laeviceps* Ashm. has previously been reared from *S. epigaea* (Wood, 1951), but not during the period covered by this paper.

Larvae of *Microplitus* sp. near *autographae* Mues. and *Microplitus* sp. emerged from host larvae and pupated between May 13 and June 18. The mean pupal duration for the former species was 16 days and the latter 13 days. One

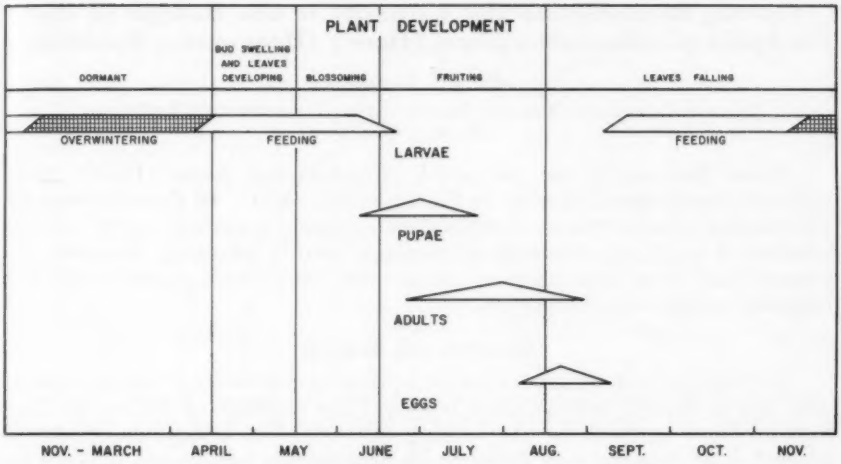

Fig. 1. Seasonal development of *S. epigaea* in relation to the development of low-bush blueberry.

specimen of *Microplitus varicolor* Vier. emerged from a host larva and pupated on October 6 and the adult parasite emerged on October 15.

One specimen of *Rogas parasiticus* (Norton) emerged from a host larva and pupated on June 7 and the adult parasite emerged on June 30.

Ichneumonidae

One specimen of *Ichneumon* sp. emerged as an adult from a host pupa on July 16.

Larvae of *Campoletis perdistinctus* (Vier.) emerged from host larvae and pupated in October and in May. Pupal duration ranged from 11 to 31 days with a mean of 20 days. *Campoletis* sp. emerged from host larvae and pupated May 3-24; pupal duration ranged from 13 to 31 days.

Larvae of *Hyposoter annulipes* (Cress.) emerged from host larvae and pupated in October and in May; pupal duration ranged from 16 to 28 days, with a mean of 24 days.

Encyrtidae

Larvae of the polyembryonic parasite *Copidosoma truncatellum* (Dalm.) emerged as adults from full grown host larvae. The host larva partially spins a cocoon and then dies as the parasites begin to pupate. Adult parasites emerge in late August and early September.

The hyperparasite *Mesochorus* sp. (Hymenoptera: Ichneumonidae) has been reared from two host larvae.

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Growth, Reproduction and Longevity in one Biotype of the Pea Aphid, *Acyrthosiphon pisum* (Harr.) (Homoptera: Aphididae)

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Three biotypes of the pea aphid, *Acyrthosiphon pisum* (Harr.), were reported from Southern Quebec by Cartier (1957, 1959). Of these, biotype R1 was adopted as the standard culture in studies of aphid resistance in peas. As the criterion of weight of individuals is frequently used in measuring resistance, the present study was undertaken to secure data on growth, reproduction and longevity of aphids of this biotype.

Materials and Methods

Twenty-three nymphs, born within a period of four hours in a stock culture, were placed on five uniform three week-old pea seedlings of the variety Perfection, *Pisum sativum* L. At varying intervals, five individuals, randomly selected, were weighed on a Roller-Smith microtorsion balance and replaced on the plants. The number of exuviae were recorded twice daily in order to follow the development of the nymphs to the adult stage. The first five nymphs to reach the adult stage were transferred to separate seedlings. Their weight was recorded daily and their progeny counted and killed. The plants, grown in sandy-loam in six-inch flower pots, were renewed weekly.

Automatic controls maintained the greenhouse compartment at 69 $\pm$ 2°F., 50 $\pm$ 5 per cent relative humidity and a photoperiod of 16 hours. Vertical temperature gradients were avoided by circulating the air with an electric fan. Hourly temperature readings were obtained from a calibrated thermograph and all temperatures above Merriam's developmental threshold of 43°F. (Harrington, 1943) were transformed into effective degree-hours (hereinafter referred to as E.D.H.): e.g., 5 hours at 68°F. and 10 hours at 70°F. yielded (68-43) $\times$ 5 + (70-43) $\times$ 10 = 395 E.D.H.

Results and Discussion

The curve obtained (Fig. 1) by plotting the average weight of nymphs against the E.D.H. was not continuous. As moulting approached the nymphs ceased feeding and lost weight for periods estimated graphically at six hours in the first instar and nine hours in the fourth. This may be related to the fact that fourth instar nymphs stop excreting for a mean period of 10 hours at moulting (Auclair, 1960). Corresponding periods for the second and third instar occurred during the night and could not be measured.

The growth ratios between the nymphal instars somewhat exceeded those expected from Przibram's rule (Wigglesworth 1939). However, the rate of body weight increase was doubled in the first three instars and nearly so in the fourth and the adult (Table I).

The adult life was first characterized by a pre-reproduction period averaging 43 hours during which the females gained weight at the rate of 0.051 mg. per hour mainly because of their developing embryos. Reproduction began with eight days of intensive parturition at a mean rate of 9.7 nymphs per female per day. This rate multiplied by the weight of nymphs at birth gave a total of 1.083 mg. of "living matter" per day or 0.046 mg. per hour. Since during this early period of reproduction the weight of the female averaged 4.500 mg., the

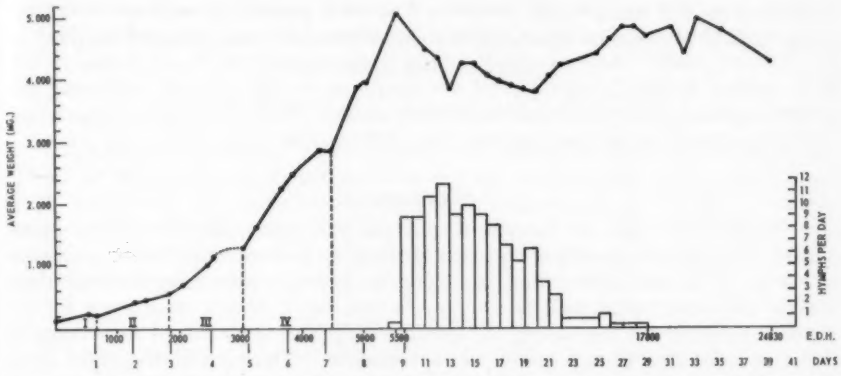

Fig. 1. Growth curve, rate of reproduction and longevity of biotype R1 of *A. pisum* at 69°F. Each point on the curve and each column in the histogram is the average of five separate measurements.

apterous female was capable of transforming plant sap into live embryos in the proportion of 24 per cent of her own body weight per day. In the twelve days that followed, the rates of births diminished gradually and totalled an average of 106.3 nymphs for the entire period of reproduction. In the post-reproduction stage the females remained ten days at a more or less constant weight, their abdomen being partially transluscent because of the absence of embryos. They all died during the 39th day.

Harrington (1941), rearing a pure line of *A. pisum* on Perfection peas, established the duration of the four nymphal instars and of the period between last moult and parturition at respectively 35.0, 36.6, 40.9, 45.3 and 20.6 hours. The differences with the data listed in Table I are undoubtedly due to his experiments being run at an unspecified higher temperature that resulted in an accelerated nymphal development and a reduction of ten days in the life span. In other tests by the same author (1943), reproduction at the close of five eight-day trials at 70 ± 2°F. ranged from 68 to 72 nymphs per female. In similar tests, our

TABLE I

Duration and growth characteristics of the developmental stages of biotype R1 of *A. pisum* at 69°F. St. Jean, Que., February 1958.

	Nymphal instars				Last moult to reproduction
	I	II	III	IV	
Hours	26	45	46	55	43
Cumulative		71	117	172	215
E.D.H.*	676	1179	1273	1466	1038
Cumulative		1855	3128	4594	5632
Average maximum weight (mg.)	0.225	0.582	1.295	2.873	5.077
Weight increase ratio	2.00**	2.58	2.22	2.22	1.76
Average weight increase (mg./hr.)	0.004	0.008	0.016	0.029	0.051

*Effective degree-hours
**Calculated on the initial average weight of 0.112 mg.

average was 77.3 nymphs per female. The total progeny results are in agreement with those of Harrington (1941): 106.4 and 109.7 as compared to 106.3 in the present study. Kenten (1955), rearing pea aphids on Broad beans (*Vicia faba*, variety Seville Longpod), did not obtain more than 77 to 86 offspring per parent. Although both workers reared a pure line stock at the same temperature and photoperiod, results suggest that two different biotypes were involved.

Summary

Weight variations in biotype R1 of the pea aphid, *Acyrthosiphon pisum* (Harr.), reared on greenhouse-grown Perfection pea seedlings, were measured at 69 ± 2°F. At each instar, the nymphs slightly more than doubled their weight and interrupted their feeding six to nine hours before moulting. Forty-three hours after the last moult, the apterous virginiparae produced an average of 106.3 nymphs in a 20-day period of reproduction. During the first eight days, the daily production of nymphs was equivalent to 24 per cent of the weight of the female. The females remained ten days in a post-reproduction stage and died on the 39th day.

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Attractiveness of Some Onion Varieties Grown in Muck Soil to Oviposition by the Onion Maggot (*Hylemya antiqua* (Meig.)) (Anthomyiidae: Diptera)

By J. P. PERRON[1], J. J. JASMIN[2], AND J. LAFRANCE[1]

Experiments conducted in the greenhouse and in the field by Perron *et al.* (1958) on 44 varieties of *Allium* revealed that the varieties Nebuka[3] and Hishiko[3] of *A. fistulosum* (L.) were significantly more resistant to attacks by the onion maggot, *Hylemya antiqua* (Meig.), than varieties of *A. cepa* (L.). This is a report of experiments conducted in 1957 and 1958 in the greenhouse and in the field on the attractiveness of seven of these varieties to oviposition by *H. antiqua*.

Materials and Methods

Three greenhouse experiments were conducted at the Research Laboratory, St. Jean, during the winter 1957 and 1958. The onion varieties used and the methods employed were those of Perron *et al.* (1958). Methods were slightly modified in that flats were divided into two sections, one for egg counts and the other for plant mortality counts.

Field tests were carried out at the Horticultural Organic Soil Substation, Ste. Clothilde, Quebec, in muck soil fertilized with 2-12-10 at the rate of 800 pounds per acre. Six standard randomized blocks were laid out. Each block consisted of seven plots, two of resistant varieties and five of varieties showing various degrees of susceptibility. Each plot laid out 24 inches apart, replicated six times, consisted of one six foot row divided into two sections, one four feet in length for plant mortality counts, the other two feet in length for egg counts. Counts of eggs and plant mortality were taken three times a week during June, and once a week thereafter until harvest. Infested plants were pulled out, counted and the per cent mortality established from the remaining plants. Eggs were collected and counted every other day until the end of the test or when fifty per cent of the plants in the susceptible variety plots were killed.

Field tests under cages, one variety per cage, were also carried out with four varieties, the resistant Nebuka and Hishiko and the susceptible Beltsville Bunching and Early Yellow Globe. Each cage (six by six by three feet) replicated three times included two rows of six feet long and 15 inches apart, and was infested with 60 males and 60 females during the first week of June when the onions were from four to six inches high, and when first-generation eggs are usually found. The infestation lasted almost six weeks. The flies in the cages were fed on an artificial diet as described by Perron *et al.* (1953). Plant mortality counts were taken when first injury appeared and were continued once or twice a week until harvest in September. A final count was then made on damaged roots which had survived injury made earlier in the season. An analysis of variance on angular transformation of percentage of plants killed was made.

Results and Conclusion

For all seven varieties, the per cent plant mortality obtained in the greenhouse and in the field (Table I) was similar to that obtained by Perron *et al.* (1958). The varieties Hishiko and Nebuka were the least damaged by maggots and had a significantly smaller number of eggs indicating a marked preference for

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[3]A similar resistance by these varieties to onion maggot was found by Dr. A. G. Howit (personal communication), Western Experiment Station, Puyallup, Washington in 1957.

TABLE I

Eggs per two feet of row (A) and percentage plant mortality (B) by the onion maggot (Hylemya antiqua Meig.) and angular transformation of percentage mortality (C) in three greenhouse and two field tests of seven onion varieties.
1957-1958

Varieties	Greenhouse tests, St. Jean, Que.									Field tests, Ste. Clothilde, Que.					
	I			II			III			I			II		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
A. fistulosum (L.)															
Hishiko	5.0	23.0	28.5	16.3	19.0	23.4	40.0	16.1	23.3	64.0	10.2	18.5	8.7	18.9	25.2
Nebuka	6.0	15.5	21.7	16.5	17.3	23.6	32.5	50.9	45.8	103.8	19.4	25.1	26.8	30.5	32.8
A. cepa (L.)															
White Portugal	77.8	77.7	62.2	87.3	67.9	56.4	102.3	86.8	68.9	132.0	54.4	47.6	42.2	51.0	45.6
Red Wethersfield	42.5	73.5	59.4	103.0	50.4	45.0	146.8	59.1	50.4	229.5	50.2	45.1	55.8	59.0	50.2
Autumn Spice	52.8	69.6	58.0	36.5	72.5	58.8	103.3	78.8	66.2	145.2	64.9	54.3	51.0	57.4	49.4
A. cepa (L.) X *A. fistulosum* (L.)															
B. Bunching	8.8	62.9	56.0	42.8	21.8	25.8	72.8	63.0	53.7	158.2	47.6	43.6	68.7	61.6	52.3
A. cepa (L.)															
E. Y. Globe	27.5	72.3	58.5	66.0	45.1	42.1	119.8	81.6	65.3	194.0	53.1	47.4	130.5	67.2	57.0
L. S. D. P = 0.05	23.5		15.9	38.3		15.6	36.6		14.8	54.3		8.5	25.2		9.4
Correlation Coefficient			0.5767			0.5967			0.3680			0.5126			0.5747

TABLE II

Percentage mortality of onions and their angular transformation when exposed to onion maggot (*Hylemya antiqua*, Meig.) infestation in field cages at Ste. Clothilde, Que., 1958

Varieties	Percentage mortality	Angular transformation of percentage mortality
Allium fistulosum L.		
Nebuka	32.6	31.8
Hishiko	28.8	29.0
Allium cepa L. x *A. fistulosum* L.		
B. Bunching	30.4	31.9
Allium cepa L.		
E. Y. Globe	27.8	28.6
L. S. D. at P = 0.05		N.S.

oviposition on the other varieties. The variety Beltsville Bunching, which is a cross between *A. fistulosum* and *A. cepa* was also less attractive to adults and showed low egg deposition particularly in the greenhouse tests. A covariance analysis of results indicated that egg population had a direct influence on the mortality of some varieties, the correlation coefficient (Table I), though not very high, being consistent and significant.

When the flies were confined in cages with individual varieties, percentage mortalities did not differ significantly between varieties (Table II). This confirms the observation made previously that any differences in infestation by the onion maggot is due mostly to a preference of the adults to oviposit on some varieties rather than on others (Labeyrie, 1957).

Summary

Field and greenhouse tests of seven varieties of onions in muck soils showed that Nebuka and Hishiko varieties of *A. fistulosum* (L.) were much less attractive to oviposition by *Hylemya antiqua* (Meig.) than the White Portugal, Red Wethersfield, Autumn Spice and Early Yellow Globe varieties of *A. cepa* (L.). The hybrid Beltsville Bunching was intermediate in attractiveness between the above two groups, particularly in the greenhouse tests.

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A New Species of *Catallagia* Rothschild from Arizona (Siphonaptera: Hystrichopsyllidae: Neopsyllinae)

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In 1957 James R. Beer, Edwin F. Cook and Robert G. Schwab, of the University of Minnesota, conducted an investigation of mammals and their ectoparasites in the Chiricahua Mountains of southeastern Arizona. The area studied included varied habitats in the general vicinity of the Southwestern Research Station of the American Museum of Natural History at Portal. An account of this investigation has now been published (Beer *et al.*, 1959).

Among the sixteen species and subspecies of fleas reported was a short series of a new species of *Catallagia* Rothschild. This material was forwarded to the writer by Dr. Edwin F. Cook and is the basis for the following description.

Catallagia arizonae, new species

Belonging to the *charlottensis*-group of the genus and most suggestive of *C. decipiens* Roths. and *C. mathesoni* Jam., from both of which, however, it is abundantly distinct in the male; not so distinct in the female.

Male

Ocular setae four or five, in a nearly even row, as in *C. charlottensis;* about six frontal setae (Fig. 1). Postantennal region with two oblique rows of setae in addition to a submarginal one. A small fronto-clypeal tubercle present. Eye reduced, as in other species of the genus. Labial palpus five-segmented, and approximately two-thirds as long as fore coxa. Second antennal segment with short setae.

Structure and chaetotaxy of thorax essentially as in other species of the genus. Pronotal comb of about 14 broad spines. Two or three pseudosetae on each side, under the collar of the mesonotum; metanotum lacking pseudosetae.

Hind coxae with a row of spiniform setae, and abdominal segment II with a lateral "striarium". Tarsal segments V of fore- and mid-legs with four lateral pairs of plantar bristles and a basal submedian pair; tarsal segment V of hind-leg with four lateral pairs.

Apical spinelets of abdominal terga as follows: I, 1 spine per side; II, 2 spines (or 1); III, 1 spine; IV, 1 spine. Abdominal terga II-VII each with two rows of setae, the anterior row of about nine short setae and the posterior row of about seven long setae, those of the posterior row alternating with fine intercalary hairs. Spiracles of abdomen small.

Typical sternum with a row of about three well-developed setae preceded by one or two fine setae.

Antesensilial setae three, of the usual proportions for the genus. Sternum VIII broad, bearing ventrolaterally about three strong setae and one or two weak ones; caudal margin with narrow sinus and long flap-like process.

Clasper broad (Fig. 2) with broad, strongly curved manubrium. Fixed process of clasper rounded and fringed with short setae, the distal ones submarginal; an acetubular seta. Movable process long and narrow, its posterior margin concave as in *C. neweyi* Holland and Loshbaugh, and its anterior margin with articular process set below mid point. Lower lateral surface of movable process with about twenty setae (Fig. 4) and posterior margin with a few short, scattered, setae. Three unmodified, mesal, submarginal setae on lower angle of

Figs. 1-6. *Catallagia arizonae* n. sp. 1, Head and pronotum of male (paratype). 2, Terminal abdominal segments of male (holotype). 3, Enlarged detail of apex of ventral arm of sternum IX of male (a, holotype; b, paratype). 4, Enlarged detail of movable process of clasper of male (paratype). 5, Terminal abdominal segments of female (allotype). 6, Enlarged detail of spermatheca.

movable process[1]. Sternum IX very distinctive; distal arm narrowed at the apex and terminating in a large, pigmented, spiniform seta preceded by two short, curved, spiniforms (Fig. 3). Proximal to the spiniforms a short, claw-like, seta and a long, slightly hooked, seta, very broad at the base. Other setae, dorsally, ventrally, and mesally, as illustrated.

Female

Details of chaetotaxy essentially similar to those of the male.

Second antennal segment with marginal setae about half as long as the club.

Anal stylet about three times as long as broad; a long apical seta with a minute seta at its base. Stigma cavity narrow. Sternum VII similar to that of *C. charlottensis* (Baker) with almost no sinus (Fig. 5). Sternum VII with about six long setae and eight light ones. Spermatheca (Fig. 6) as in all species of *Catallagia*.

Size (mounted specimens): ♂, average 2.0 mm.; ♀, average 2.2 mm.

Holotype.— ♂, Portal, Arizona, 8000′, August, 1957, collected from *Peromyscus boylei* (Baird) by J. R. Beer and R. G. Schwab.

Allotype.— ♀, same data, except from *Peromyscus maniculatus rufinus* (Merriam).

Paratypes.—4 ♂♂, 5 ♀♀ as follows: same data as allotype, 2 ♂♂, 1 ♀; Chiricahua Mts., 8600′, ex *Peromyscus maniculatus*, 6.VII.60, 2 ♀♀, collected by R. W. Thorington; one-half mile east of Ranger Station, Chiricahua Mts., 8700′, ex *P. maniculatus*, 30.VII.60, 1 ♂, 1 ♀, R. W. Thorington; Barfoot Turnoff, near Rustler's Park, Chiricahua Mts., ex *Peromyscus* sp., 8.IX.60, 1 ♂, 1 ♀, H. F. Howden.

Holotype and allotype deposited in the collection of the Department of Entomology and Economic Zoology, University of Minnesota, St. Paul. Paratypes No. 7155 in the Canadian National Collection of Insects, Ottawa.

Reference

Beer, James R., Edwin F. Cook, and Robert G. Schwab. 1959. The ectoparasites of some mammals from the Chiricahua Mountains, Arizona. *J. Parasitol.* 45: 605-613.

[1]Virtually all species of *Catallagia* and the related genus *Epitedia* Jordan (except the aberrant species *C. borealis* Ewing and *E. scapani* (Wagner)) have two or three mesal setae in this position. In most species they are relatively unmodified and easily confused with similar setae on the margin or on the outer surface of the movable process. In *Epitedia faceta* (Rothschild), however, they are somewhat enlarged and hook-like as they also are in *Catallagia jellisoni* Holland, and several Russian species. In *C. neweyi* Holland and Loshbaugh they are extremely large and modified in a fashion that suggests a specialized function, perhaps in the mating act.

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A New Species and a New Subgenus of *Sitomyzus* Hille Ris Lambers (Homoptera: Aphididae)

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Sitomyzus was erected for a grass-feeding species of aphid, *S. vibei* H.R.L. which is known to occur only in Greenland (Hille Ris Lambers, 1952). In this paper a second species is described from British Columbia, and a third, common, widespread species, *Rhopalosiphum rhois* Monell, is also assigned to this genus. The latter species is placed in *Sitomyzus* largely on the basis of similarities between the alate viviparae of *rhois* and those of other representatives of this genus. The apterae of *rhois* are very distinct however, and a new subgenus is herein erected for this species.

The life-histories of the three species placed in *Sitomyzus* are unknown or have been very poorly investigated. Two of the species have been associated only with grasses. The third, *rhois*, is best known for its association with various species of sumac (*Rhus* sp.) but Gillette and Bragg (1915) and Palmer (1952) also recorded *rhois* from various species of grasses including cereal crops.

The two subgenera and three species of *Sitomyzus* can be distinguished as follows:

1. Much of the dorsum in the apterae wrinkled; frontal tubercles in apterae almost parallel, scabrous: intersegmental sclerites in alatae transversely elongate; fourth antennal segment in alatae with a few sensoria 2
Dorsum of abdomen in apterae not wrinkled; frontal tubercles diverging, smooth or nearly so; fourth antennal segment in alatae without sensoria ..... *S.* (*Glabromyzus*) *rhois* (Monell) new combination

2. Third antennal segment in alatae with 29-32 secondary sensoria; third and fourth antennal segments in apterae each less than 0.3 mm. long; apical rostral segment in apterae and as long as the second segment of hind tarsus ..... *Sitomyzus columbiae* new species
Third antennal segment in alatae with fewer than 10 sensoria; third and fourth antennal segments in apterae each 0.3 mm. or more; apical rostral segment in alatae and apterae shorter than second segment of hind tarsus ..... *Sitomyzus vibei* H.R.L.

Subgenus *Glabromyzus*, new subgenus

Type species: *Rhopalosiphum rhois* Monell. 1879. Bull. U.S. Geol. Geog. Surv. 5: 27.

Apterous Viviparous Female.—Similar to *Sitomyzus* but with smooth, diverging frontal tubercles and dorsum of body unwrinkled.

Alate Viviparous Female.—Similar to *Sitomyzus* but fourth antennal segment without sensoria and intersegmental sclerites circular or nearly so.

***Sitomyzus* (*Glabromyzus*) *rhois* (Monell)**

1879. Monell, J. Bull. U.S. Geol. Geog. Surv. 5: 27. *Rhopalosiphum rhois.*
1915. Gillette, C. P., and L. C. Bragg. J. Econ. Ent. 8: 100. *Rhopalosiphum rhois.*
1931. Hottes, F. C., and T. H. Frison. Bull. Ill. Nat. Hist. Surv. 29: 240. *Rhopalosiphum rhois.*
1932. Gillette, C. P., and M. A. Palmer. Ann. Ent. Soc. Amer. 25: 448. *Rhopalosiphum rhois.*
1952. Palmer, M. A. Thomas Say Foundation 5: 220. *Rhopalosiphum rhois.*

Apterous Viviparous Female.—Frontal tubercles well developed, smooth, diverging, each tubercle with one or two short, blunt setae. Median tubercle smooth, fairly well developed. Disc of head smooth, with eight short, blunt setae. Venter of head smooth, antennae six-segmented. Lengths of antennal segments: III, 0.5-0.625 mm.; IV, 0.35-0.475 mm.; V, 0.3-0.35 mm.; VI, 0.175 mm. + 0.45 mm. Antennal segment III without secondary sensoria; primary sensoria with ciliated margins. Antennal setae short, blunt, the longest ones about one-fourth the basal diameter of segment III. Antennal segments I and II imbricated. Rostrum reaching to second coxae; the apical segment 0.125 mm. long, with two setae in addition to the usual three apical pairs and minute basal pair. Dorsum of prothorax with four blunt setae each about as long as those on disc of head; surface smooth. Short blunt, or distinctly capitate setae on femora and basal two-thirds to three-fourths of tibiae; pointed setae elsewhere on tibiae. Femora very weakly scabrous; hind tibiae 1.2-1.7 mm. long. Second segment of hind tarsus 0.15 mm. First tarsal segments each with three setae. Abdomen without lateral tubercles or pigmented sclerotic areas; dorsum smooth, unwrinkled. Setae on abdominal terga short, blunt on terga I-VII, pointed or blunt on tergum VIII. Venter of abdomen with spiculose imbrications; setae pointed and arranged in two irregular transverse rows on each segment. Three setose gonapophyses.

Cornicle 0.45-0.525 mm. long, strongly swollen on apical half, with scattered, faintly spiculose imbrications. Anal plate strongly spiculose, with pointed setae. Subgenital plate weakly spiculose, with blunt setae along posterior margin. Cauda elongate with two pairs of setae on each side and one or two dorsal preapical ones. Spiracles reniform. Colour when alive: Light to dark brown. Colour when macerated: Essentially as in aterous viviparous female of *S. columbiae*. Length 2-2.5 mm. when mounted.

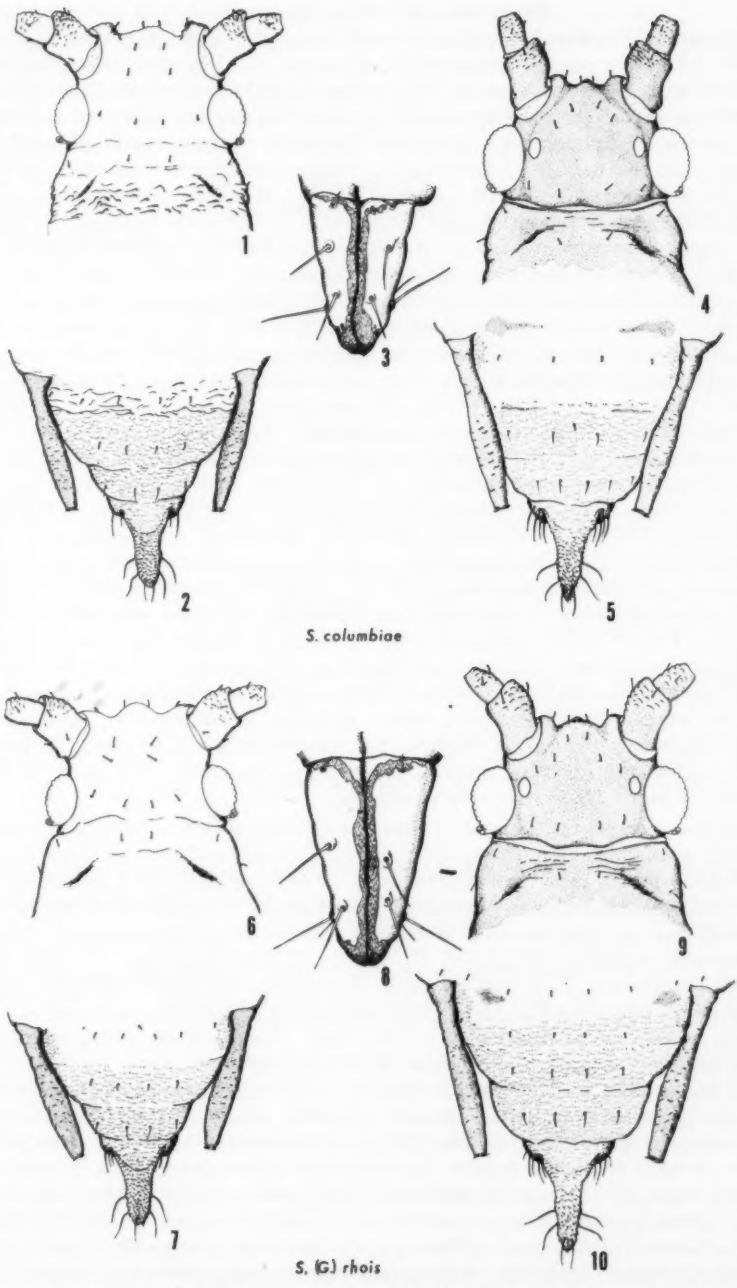
Alate Viviparous Female.—Frontal tubercles well developed, diverging, smooth, each with one or two short, blunt setae. Venter and disc of head smooth. Disc of head with eight, short, blunt setae. Antennal segments I and II scabrous, with pointed, or minutely blunt setae. Antennal segments III-VI with well developed, smooth imbrications. Antennal segment III with three to eight secondary sensoria; other segments without sensoria. Antennal setae pointed or minutely blunt, the longest ones about one-third the basal diameter of segment III. Lengths of antennal segments: III, 0.45-0.6 mm.; IV, 0.4-0.55 mm.; V, 0.3-0.45 mm.; VI, 0.15-0.2 mm. + 0.6-0.7 mm. Rostrum extending to middle coxae, apical segment 0.125-0.15 mm. long, with two setae in addition to the usual three apical pairs and minute basal pair. Venation of wings normal, veins narrowly bordered with fuscous pigment. Setae on legs mostly short, pointed, sometimes blunt or minutely capitate on femora and basal halves of tibiae. Hind tibia 1.275-1.85 mm. long. Second segment of hind tarsus 0.125-0.15 mm. long. Each first tarsal segment with three setae. Lateral abdominal tubercles absent. Lateral abdominal sclerites well formed. Abdominal terga I-VII with short, blunt or minutely capitate setae; tergum VIII usually with longer, pointed setae. Intersegmental sclerites present, roughly circular. Cornicle 0.4-0.45 mm., strongly swollen at middle, sparsely imbricated. Subgenital plate with spiculose imbrications and blunt setae along posterior margin. Anal plate strongly spiculose, with pointed setae. Cauda elongate, with two pairs of lateral setae and one or two dorsal preapical ones. Colour when alive: Brown. Colour when macerated: Antennae, head, rostrum, thorax, legs, lateral abdominal sclerites and cornicles dark brown; elsewhere colourless or light brown. Length when mounted 1.7-2.2 mm.

Distribution.—Very widespread in North America, occurring wherever species of sumac (*Rhus* sp.) are to be found. Specimens examined from: ONT. on *Rhus typhina* L., *Rhus* sp.; MAN. on *Rhus glabra* L.; ILL. on *Rhus glabra* L.; N.B. on *Rhus typhina* L., *Rhus* sp.

Comments.—*Amphorophora howardii* Wilson, which has been considered to be the grass-infesting form of *rhois* (Gillette and Bragg 1915, Palmer 1952) has not been included in the present discussion because the association of these two forms has not been confirmed by experimental transfers. There is no doubt that the two forms, or possibly two species, are very closely related, and on the basis of material examined, the only difference appears to be the presence of fairly well defined, pigmented, transversely elongate, scerotic patches on the abdominal terga in *howardii*[1].

S. (*Glabromyzus*) *rhois* has been erroneously assigned to *Rhopalosiphum* Koch, but the similarities are superficial, the relationship being largely based on the strongly swollen cornicles. However, like other species of *Sitomyzus*, *rhois* can readily be distinguished from species of *Rhopalosiphum* by the presence of three setae on each of the first tarsal segments and complete absence of lateral tubercles.

[1]The relationships of *rhois* and *howardii* are being investigated by Professor C. F. Smith, North Carolina State College, Raleigh, N.C.



Figs. 1, 6. Dorsa of heads and of prothoraxes of apterous viviparous females. Figs. 2, 7. Dorsa of apices of abdomens of apterous viviparous females. Figs. 3, 8. Apical rostral segments of apterous viviparous females. Figs. 4, 9. Dorsa of heads and prothoraxes of alate viviparous females. Figs. 5, 10. Dorsa of apices of abdomens of alate viviparous females.

***Sitomyzus columbiae*, new species**

Apterous Viviparous Female.—Frontal tubercles well developed, scabrous, parallel or nearly so; each tubercle with one or two, short, blunt or minutely capitate setae; median tubercle prominent, slightly scabrous. Disc of head smooth or slightly wrinkled; with short, blunt or capitate setae, of which the four nearest to the posterior margin are distinctly shorter; venter of head with minute scattered spicules. Antennae six-segmented, shorter than body, primary sensoria with coarsely ciliated margins; segment II with one or two secondary sensoria near base. Antennal setae short, blunt or distinctly capitate, the longest ones equal to about one-fourth the basal diameter of antennal segment III. Lengths of antennal segments: III, 0.4-0.48 mm.; IV, 0.25-0.3 mm.; V, 0.25-0.3 mm.; VI, 0.125-0.126 mm. + 0.47-0.6 mm. Antennal segments I and II strongly scabrous. Rostrum short, not reaching middle coxae; apical segment 0.1 mm. long, with two setae in addition to the usual three apical pairs and minute basal pair. Dorsum of prothorax with four, short, blunt inconspicuous setae, slightly wrinkled on posterior half. Setae on legs short, blunt, except on tarsi and extreme apices of tibiae where they are pointed. Femora with spiculose imbrications which are especially evident on apical halves. Hind tibia 1.15-1.35 mm. long. Second segment of hind tarsus 0.1-0.12 mm. long. First tarsal segments each with three setae. Abdomen without lateral tubercles or pigmented sclerotic areas; terga I-V or VI distinctly wrinkled. Setae on abdominal terga I-VII short and blunt, longer and mostly pointed on tergum VIII. Venter of abdomen with faint, spiculose imbrications; with two irregular, transverse rows of pointed setae on each segment. Subgenital plate wrinkled, with blunt seta along posterior margin. Three setose gonapophyses. Cornicle 0.4-0.48 mm. long, strongly swollen on apical half, with scattered spiculose imbrications. Anal plate strongly spiculose, with pointed setae. Cauda with two curved pointed setae on each side and one or two dorsal preapical ones. Spiracles almost circular, slightly reniform. Colour when alive: Unknown. Colour when macerated: Antennae, apical segment of rostrum, most of legs light brown, tarsi and apices of tibiae darker. Length 2-2.25 mm. when mounted.

Alate Viviparous Female.—Frontal tubercles well developed, diverging, smooth, each with two short, blunt setae. Venter and disc of head smooth. Disc of head with eight short blunt setae. Antennal segments I and II strongly scabrous; segment III lightly imbricated, with 29-32 secondary sensoria; segment IV with five to eight sensoria; V and VI without secondary sensoria. Lengths of antennal segments: III, 0.55-0.575 mm.; IV, 0.335-0.35 mm.; V, 0.335 mm.; VI, 0.125-0.14 mm. + 0.62-0.625 mm. Antennal setae short, blunt, the longest about one-fourth the basal diameter of segment III. Rostrum short, not reaching middle coxae; apical segment 0.1 mm. long. Venation of wings normal, all veins narrowly bordered with faint brownish pigment. Setae on legs mostly blunt except near apices of tibiae and on tarsi where they are sharply pointed. Lateral abdominal sclerites present. Lateral abdominal tubercles absent. Abdominal terga I-VII with short, blunt, setae; tergum VIII with four pointed setae. Venter of abdomen with two irregular, transverse rows of pointed setae on each segment. Dorsum of abdomen largely smooth except for tergum VII and VIII. Intersegmental sclerites present, transversely elongate. Cornicle 0.35 mm. long, strongly swollen near middle, sparsely imbricated, subgenital plate, weakly spiculose, slightly wrinkled, with pointed setae along posterior margin. Anal plate strongly spiculose with pointed setae. Cauda elongate, with two pairs of pointed, lateral setae and two dorsal preapical ones. Colour when alive: Unknown. Colour when macerated: Antennae, head, apical rostral segment, ptero-

thorax, legs, lateral and intersegmental abdominal sclerites, cornicles and anal plate dark brown; elsewhere light, diffuse brown or colourless. Length when mounted 2 mm.

Holotype.—Alate viviparous female, Vancouver, B.C., May 7, 1958 (K. Graham), on grass. No. 7122 in Canadian National Collection.

Paratypes.—Four apterous viviparous females. Same data as for holotype.

Summary

A new species and new subgenus of *Sitomyzus* are described and illustrated. A key to known species is given.

Acknowledgments

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Notes on the Life-history and Habits of the Brown Mite, *Bryobia arborea* Morgan & Anderson (Acarina: Tetranychidae), on Peach in Ontario

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The 'clover' mite, *Bryobia praetiosa* Koch, has long been known to be a complex of closely related species or biological races differing greatly in host range, life-history, and habits. Morgan and Anderson (1957) reviewed the problem and described the form occurring on fruit trees in British Columbia as a new species, *B. arborea*, to be known as the brown mite, and these authors (Anderson and Morgan, 1958) also published a detailed study of the life-histories and habits of this species and of the true clover mite, *B. praetiosa*. Although the presence of *Bryobia* mites on fruit trees in Eastern North America, including Ontario, has long been recognized, they have seldom received more than casual mention and no extensive study of their biology in this area appears to have been undertaken. The species has little economic importance in Ontario (Putman and Herne, 1959).

Mr. C. V. G. Morgan, Research Station, Canada Department of Agriculture, Summerland, B.C., examined specimens from peach, plum, cherry, and apple from the Niagara Peninsula of Ontario and stated (in litt.) that they were morphologically identical with *B. arborea* from British Columbia. Some data on this species accruing from a study of the relations between phytophagous mites and their predators in Ontario peach orchards will be presented as they bear on the question whether the morphological similarity between the mites from Ontario and British Columbia is parallelled by similarities in life-history and habits.

Methods

The work was conducted at the Ontario Horticultural Experiment Station, Vineland, Station, in a block of mature Veteran peach trees which received a dormant application of bordeaux mixture each year. In 1956, samples were taken in a plot that did not receive any summer applications of pesticides after 1953, and in another plot that received three sprays of DDT during the season. The data from the DDT plot will not be given as they parallelled those from the other plot in all respects except for a greater population density, which has been considered elsewhere (Putman and Herne, 1959). In 1957 samples were taken only in the unsprayed plot. In 1956 eight trees and in 1957 at first ten and later eight or five trees were sampled in each plot at weekly or bi-weekly intervals on the dates indicated in Fig. 1. The time required to count the increasing numbers of mites and especially eggs forced a reduction in the number of sample trees and an increase in the sampling interval as the season progressed. Single trees were also sampled during the latter part of the season on weeks alternating with the bi-weekly sampling of larger numbers, but they did not reveal any significant changes not shown by the larger samples and the results will not be given.

The sampling unit was a twig comprising six inches of year-old wood bearing two lateral spur-like shoots each not more than three-quarters of an inch long and a terminal shoot not more than six inches long, of the current season's growth. This unit was designed to obtain numbers of mites on leaves from different positions on the twigs, and the comparative numbers on leaves and twigs of different ages. The unit was more or less representative of the foliage on the tree as a whole, as estimated by observation of the growth habits of the trees. Ten twigs were collected from each sample tree, one from the inside and one near the outer part at each of five approximately equidistant positions about the tree.

The leaves were clipped off and brushed in a Henderson-McBurnie mite-brushing machine and the woody parts of the twigs were carefully examined under a stereoscopic microscope. In 1956, only young (larvae, protonymphs, and deutonymphs) and adult females were counted; in 1957 eggs were also included. Males do not occur in *B. arborea* or other forms of the *praetiosa* complex.

Results

Life-History.—The early development of the first generation was not followed in 1956. In 1957 many larvae had hatched by April 29. In 1959, a relatively late season, the first larvae hatched on April 30, when the more advanced leaf buds on peach showed about one-quarter inch of green tip, and all had apparently hatched by May 20, when about 60 per cent of the blossoms had opened. This hatching period appears to be much shorter than that reported by Anderson and Morgan (1958) in British Columbia, but these authors found that very few larvae hatched during the last two weeks or more of the period. In

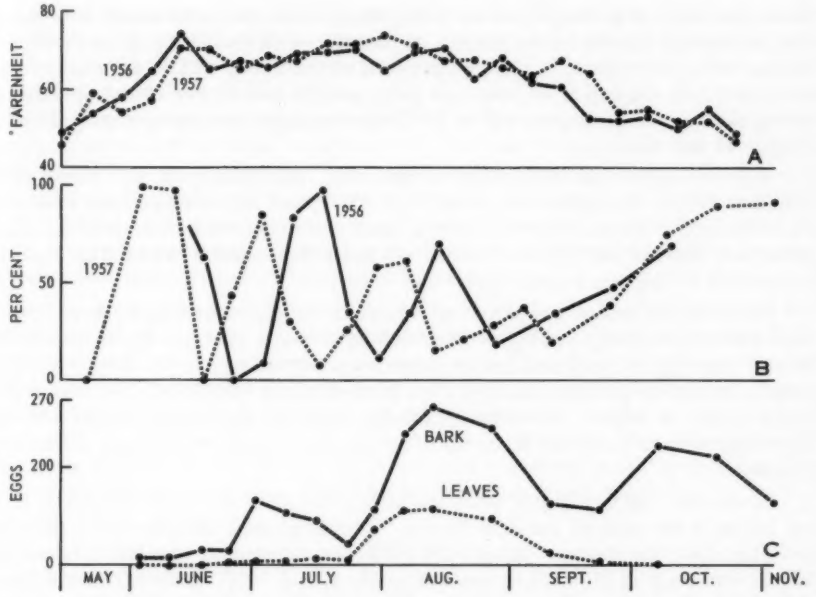

Fig. 1. The brown mite on peach in Ontario. A, weekly averages of mean daily temperatures, Vineland Station; B, percentages of adults among motile forms; C, numbers of eggs per tree sample on leaves and bark.

1957 the first adults had matured very shortly before May 22, and in 1959 the first matured on May 25.

Subsequent development of the generations in 1956 and 1957 is shown in Fig. 1, B, which gives the percentages of the motile stages that were adults. In 1956 there were clearly four generations; in 1957 there was some indication of a small fifth generation of adults at the end of August, but the data did not show this conclusively because the generations overlapped considerably by that time. Miller (1925) found at least four generations in Ohio, Lienk and Chapman (1951) five in New York, and Anderson and Morgan (1958) four in British Columbia; in all these cases the host was apple. Development of all generations in 1957 was from one to two weeks earlier than the corresponding ones in 1956. This advance must have been due to unusually warm weather during the hatching period in late April in 1957, when mean daily temperatures averaged 10.6 and 13° F. higher during the weeks ending April 22 and 29 respectively than in 1956. Temperatures during the rest of the season were rather similar in both years (Fig. 1, A).

Anderson and Morgan (1958) made the interesting discovery that an increasing portion of the eggs of each generation during the season remains in diapause until the following year. Whether the eggs behave similarly in Ontario was not directly determined but they appear to do so, for some unhatched eggs were present throughout the season (Fig. 1, C) even at times in the early summer when the mites were almost entirely in the nymphal stages.

Distribution on the Trees.—Usually less than half of the mites were found on the leaves; most of them move to the bark of year-old or older twigs to rest, moult, or oviposit, chiefly at the junctions between successive season's growth

where the surface is roughened by the scars of bud scales, or about leaf scars. The percentage on the leaves tended to increase with increasing growth of the foliage during the season; in 1956, 40 per cent of the young and 41 per cent of the adults were on the leaves in June and July, and 45 and 47 per cent respectively during the rest of the season, and in 1957 the respective percentages were 25 and 31, and 43 and 47.

The movement to the twigs agrees with that observed by Lienk and Chapman (1951) on apple in western New York, and by other authors cited by Anderson and Morgan (1958), but the latter authors found that after the first generation most of the mites remained on the foliage except when they moved to the bark to deposit winter eggs.

Early in the season twigs arising near old, rough-barked limbs bore many more mites than twigs arising farther out on smooth year-old limbs, probably because the rougher bark had borne more overwintered eggs. On May 22, 1957, samples of ten twigs from old limbs on each of three trees bore 505, and from young limbs, 16 mites. The mites gradually dispersed during the season and by September 4 their numbers on twigs from the two situations did not differ appreciably.

Noticeable feeding injury even in the heaviest infestation was confined to a few leaves at the base of the new shoots. This suggested that the mites did not move far along the shoots. Mites were therefore counted on two leaves taken on July 22 and August 23, 1957, at approximately 1, 3, 5, and 7 inches from the base of each of 50 shoots at least 10 inches long. Totals of 276 and 714 mites were found at the respective dates; their percentage distribution at the different positions along the shoots was:—

	1 in.	3 in.	5 in.	7 in.
July 22	76	16	5	3
Aug. 23	65	26	6	3

The females of all generations deposited many more eggs on the bark of the twigs than on the leaves (Fig. 1, C). On the twigs they were laid almost entirely on rough surfaces of year-old or older wood, especially about bud scale and leaf scars where moulting and resting of young and adults also took place. Sometimes most of the eggs on a twig were packed within dry, curled-up bud scales which often adhere through most of the summer, or in crevices formed when the abscission layer loosens from the previous year's leaf scars. Many eggs are lost as these deciduous parts are gradually shed during the season. Although some eggs were found on the bark or larger branches several inches from foliage, few or none were deposited lower down on the trunks. Anderson and Morgan (1938) likewise found that the adults did not move to the trunks to oviposit.

The eggs on the leaves were summer ones, for all had hatched by the end of the season. Those on the bark comprised both diapause or winter eggs, and summer ones, for many eggs were observed hatched or hatching and the total number decreased between generations (Fig. 1, C). Not all of this decrease was attributable to hatching, however, for large number were also lost through the previously mentioned fall of bud scales and abscission layers.

Discussion

It is apparent that the life-history of the *Bryobia* species on peach in Ontario differs little, if at all, from that on apple in British Columbia. The possible occurrence of an additional, partial fifth generation in some seasons in Ontario may

be due to seasonal or regional climatic differences. The habits are also basically similar, but in Ontario the motile stages spend much more time on the bark. This might be due to the different hosts, the mites on peach being able to move freely between the leaves and bark on peach because of its glabrous foliage and shorter petioles, but this supposition is unlikely because the habits of the mite on apple in western New York are apparently the same as on peach in the contiguous Niagara Peninsula of Ontario. Also, the authors have seen brown mites massed on the bark of apple and plum trees throughout the season at Vineland Station. This difference between the Ontario and British Columbia strains of the mite may have a genetic basis, but nevertheless it is much too slight to invalidate the conclusion that both belong to the species *B. arborea*.

The tendency of the brown mite to feed mostly on leaves nearest the base of the shoots may act as a population-limiting factor and partly account for the failure of this species to become a serious pest in Ontario, although its relatively slow rate of development in comparison with other common tetranychids may be another factor. In vigorous, well-pruned peach orchards most of the foliage is borne on long shoots beyond reach of the mites, although three or four smaller leaves at the base of a shoot may be very severely injured, possibly reducing their nutritional value to the mite and reducing the latter's fecundity.

Summary

The brown mite has four and in some seasons possibly five generations per year on peach in Ontario. Some females of most, and possibly all, generations lay diapause eggs that do not hatch until the following spring. Most individuals rest, moult, and oviposit on the bark of the twigs, and feed almost entirely on the leaves near the base of the shoots. This restriction of activity, and loss of eggs through fall of old bud scales and other plant parts, may help to limit the numbers of the mite on peach trees. Although the habits differ slightly, the form of the mite on peach in Ontario is considered conspecific with that on apple in British Columbia described as *Bryobia arborea* Morgan and Anderson.

Acknowledgments

The authors wish to thank Dr. W. H. Upshall, Director, Ontario Horticultural Experiment Station, Vineland Station, Ontario, for the use of the orchard, and Mr. C. V. G. Morgan, Research Station, Canada Department of Agriculture, Summerland, B.C., for critical reading of the manuscript.

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Bryobia agropyra, a New Species Allied to *curiosa*, from British Columbia (Acarina: Tetranychidae)[1]

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Since Summers described *Bryobia curiosa* in 1953 from an unknown host in the Mojave Desert, California, this unusual mite with the stylophore cleft mediodistally has never been reported elsewhere. In 1959, two new, closely related species were discovered: one was found at Summerland, British Columbia, and is described herein; the other was taken in California. I am indebted to Dr. F. M. Summers, University of California, Davis, Calif., for the loan of specimens of *B. curiosa* and for permitting me to examine specimens of his undescribed species from California.

Bryobia agropyra, n. sp.

Figs. 1-17

Female.—Body: length, 523μ; width, 344μ; shape similar to *B. curiosa* Summers (1953); with 16 pairs of spatulate, longitudinally ribbed, dorsal setae; all dorsal setae minutely spined on convex surface and, except for the distinctly smaller first pair of dorsal propodosomals (Fig. 8), of more or less equal size; all dorsal setae arising from lobes or tubercles.

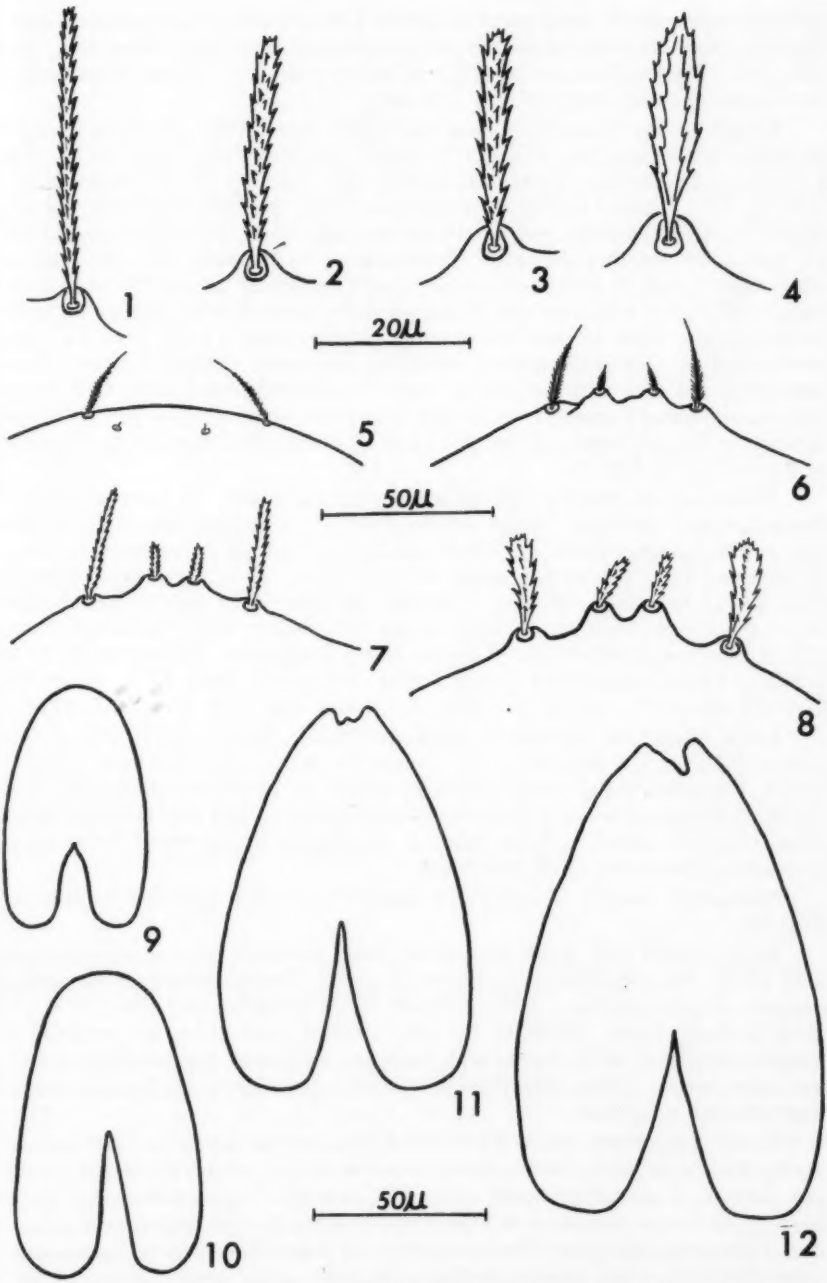
External face of palpal femur faintly sculptured with whorled granulate lines, not like *curiosa* where palpal femur granulate as on propodosoma. Palpal claw simple, not furcate or like *curiosa*. Palpal tarsus with seven setae not one of which similar to the "distinct claviform sensilla having supports in its wall" of *curiosa*.

Stylophore deeply and conspicuously cleft mediodistally (Fig. 12).

Propodosoma with dorsal integument finely granulate, granulations diminishing laterally to integrade with fine longitudinal striations near margin of body. Distinct striations absent on dorsal integument within a circular area bounded by propodosomal lobes, third pair of dorsal propodosomal setae, and just anterad of propodosomal-hysterosomal furrow. All other areas of dorsal integument of propodosoma with striations longitudinal or nearly so except for a narrow band immediately anterad of furrow where striations transverse. Propodosomal anterior lateral angulations absent. Two pairs of eyes near lateral margins of propodosoma, the posterior pair with a large refractile sphere and nearly twice the diameter of the anterior pair. Four pairs of dorsal propodosomal setae; first pair (Fig. 8) about 16μ long and 3μ wide, each borne on a small propodosomal lobe; second pair (Fig. 8) about 29μ long and 7μ wide and extending beyond first pair, each borne on a tubercle-like lobe entirely independent of median lobes and extending anteriorly only about as far as base of median lobe; third and fourth pairs arising from tubercles, third pair just anteromesad of eye, fourth pair just posterad of eye, fourth pair slightly shorter than second and third pairs.

Hysterosoma with dorsal integument coarsely striated transversely between dorsolateral setae, becoming longitudinal and fine near margin of body. Central area of dorsal integument enclosed by sacral and clunal setae faintly granulate and practically devoid of striations as illustrated for *Bryobia bakeri* (McGregor) by Pritchard and Baker (1955). No dimple-like dorsal pit or depression between inner sacral setae. Position of 12 pairs of dorsal hysterosomal setae similar to

[1]Contribution No. 36, Research Station, Research Branch, Canada Department of Agriculture, Summerland, British Columbia.



Figs. 1-12. *Bryobia agropyra*, n. sp. 1-4, shape and size of the inner sacral seta in the larva (1), protonymph (2), deutonymph (3), and adult (4); 5-8, shapes and sizes of the propodosomal lobes and the first and second pair of propodosomal setae in the four respective stages; 9-12, shape and size of the stylophore in the four respective stages.

curiosa; inner pair of sacral setae resembles a fourth pair of dorsocentral setae. Distances between paired dorsocentral hysterosomal setae: DC_1, 106μ; DC_2, 87μ; DC_3, 58μ. Distance between inner pair of sacral setae, 77μ. Dorsal hysterosomal setae about 22 to 29μ long and 5 to 7μ wide.

Length of leg I excluding coxa and tarsal claws, 489μ. Lengths of leg I segments: trochanter, 26μ; femur, 177μ; genu, 77μ; tibia, 109μ; tarsus, 100μ. Leg I 1.83 times longer than leg II, 1.65 times longer than leg III, 1.35 times longer than leg IV. Coxae I and II each with two setae, the inner ones setiform and about 45μ long, the outer ones faintly serrate and about 27μ long; coxae III and IV each with one setiform seta. Trochanters I to IV each with one seta; on trochanters I and II seta barely serrate; on trochanters III and IV seta finely serrate. Tarsus I with two sets of duplex setae, tarsus II with one set on outer dorsal surface, tarsi III and IV without duplex setae. Tarsi I to IV each terminating in a central padlike empodium and a pair of lateral claws. Each empodium and claw with one pair of ventrally-directed tenent hairs; each tenent hair on empodium I arising from at least four roots, on empodia II to IV from at least six roots; each tenent hair on claws I to IV arising from four roots. Setation of leg I shown in Fig. 16.

Measurements, based on 25 slide-mounted specimens, of some anatomical characters are as follows. Body: length, 510 $\pm$ 25μ[2] (range, 466-552μ); width, 361 $\pm$ 21μ (range, 323-402μ). Distances between paired dorsocentral hysterosomal setae: DC_1, 105 $\pm$ 7μ (range, 90-122μ); DC_2, 82 $\pm$ 6μ (range, 74-96μ); DC_3, 54 $\pm$ 3μ (range, 48-61μ). Distance between inner pair of sacral setae, 80 $\pm$ 4μ (range, 74-90μ). Length of leg I excluding coxa and tarsal claws, 505 $\pm$ 24μ (range, 443-552μ). Lengths of leg I segments: trochanter, 22 $\pm$ 2μ (range, 19-26μ); femur, 184 $\pm$ 10μ (range, 161-209μ); genu, 80 $\pm$ 5μ (range, 71-90μ); tibia, 119 $\pm$ 6μ (range, 100-128μ); tarsus, 100 $\pm$ 5μ (range, 87-112μ).

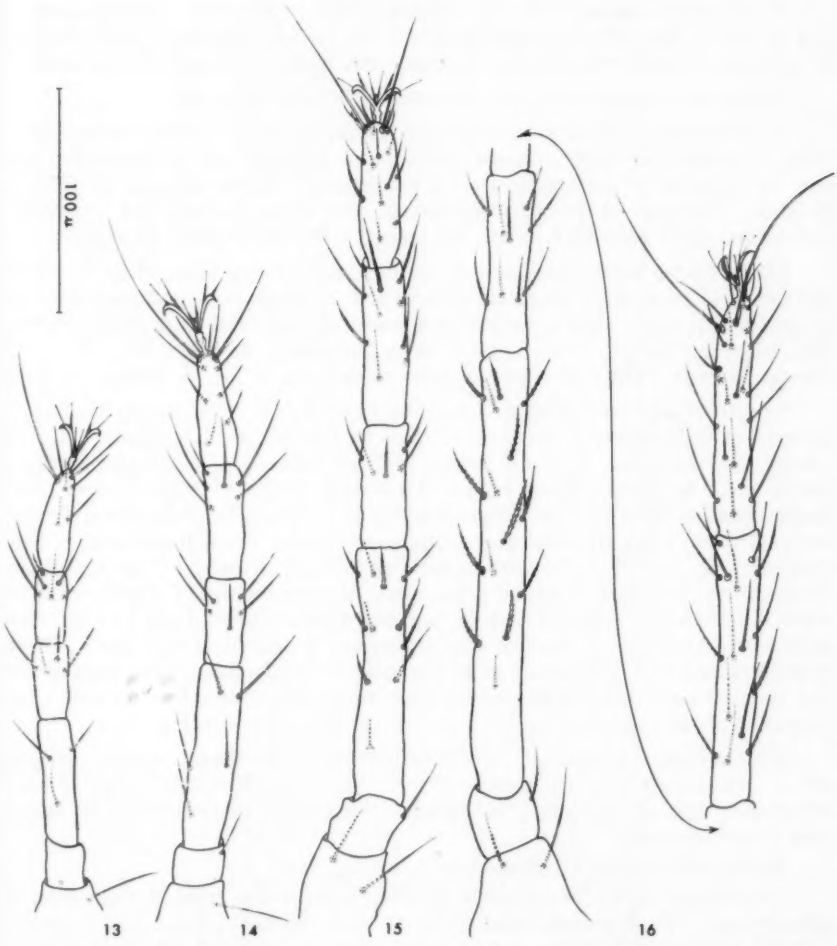
Larva.—Based on 10 slide-mounted specimens. Body: length, 224 $\pm$ 13μ (range, 201-244μ); width, 184 $\pm$ 14μ (range, 158-201μ); with 16 pairs of minutely spined, lanceolate dorsal setae, somewhat similar in length except for the very minute first pair of dorsal propodosomal setae (Fig. 5) and the distinctly larger sacral (Fig. 1), clunal, and last pair of dorsolateral hysterosomal setae; dorsal setae arising from very small tubercles.

Mediodistal margin of stylophore smoothly rounded, not cleft or indented (Fig. 9).

Propodosoma with dorsal integument finely granulate but not so extensively as in adult. Propodosomal lobes absent (Fig. 5). Two pairs of eyes near lateral margins of propodosoma. Four pairs of dorsal propodosomal setae; first pair about 3μ long, barely visible at 360 magnification, arise about 8μ proximad of anterior margin of body; second pair about 23μ long, arise from margin of body and anterolaterad of first pair; third and fourth pairs slightly smaller than second pair, situated as in adult.

Dorsal integument and setal pattern of hysterosoma similar to adult but area enclosed by sacral and clunal setae with striations, not granulate. Sacral, clunal, and last pair of dorsolateral setae about 35μ long and 2 to 3μ wide; other dorsal hysterosomal setae somewhat similar in size to second, third, and fourth pairs of dorsal propodosomal setae. Distances between paired dorsocentral hysterosomal setae: DC_1 69 $\pm$ 3μ (range, 64-74μ); DC_2, 46 $\pm$ 3μ (range, 42-51μ); DC_3, 29 $\pm$ 2μ (range, 26-32μ). Distance between inner pair of sacral setae, 23 $\pm$ 3μ (range, 19-26μ).

[2]Average and standard deviation.



Figs. 13-16. *Bryobia agropyra*, n. sp. Shape, size, and setation of leg I of the larva (13), protonymph (14), deutonymph (15), and adult (16).

Length of leg I excluding coxa and tarsal claws, 183 ± 5μ (range, 177-193μ). Lengths of leg I segments: trochanter, 15 ± 1μ (range, 13-16μ); femur, 56 ± 3μ (range, 51-58μ); genu, 29 ± 1μ (range, 29-32μ); tibia, 36 ± 1μ (range, 35-39μ); tarsus, 47 ± 3μ (range, 42-51μ). Leg I 1.3 times longer than leg II, 1.2 times longer than leg III. Coxa I with one setiform seta arising on inner surface; coxae II and III without setae. Trochanters I to III without setae. Tarsi I and II each with one set of duplex setae on outer dorsal surface; tarsus III without duplex setae. Tarsi I to III each terminating in a central padlike empodium and a pair of lateral claws. Each empodium and claw with one pair of ventrally-directed tenent hairs; each tenent hair on each empodium arising from four roots, each tenent hair on each claw arising from at least three roots. Setation of leg I shown in Fig. 13.

Protonymph.—Based on 13 slide-mounted specimens. Body: length, 312 ± 16μ (range, 287-337μ); width, 237 ± 5μ (range, 229-244μ); with 16 pairs of minutely spined, lanceolate dorsal setae, more similar in length than in larva.

Mediodistal margin of stylophore same as in larva (Fig. 10).

Propodosoma with dorsal integument similar to larva. Propodosomal lobes (Fig. 6) present but small, irregular, and variable in shape; one of the median pair may be absent in which case seta arises proximad of anterior margin of body as in larva. First pair of dorsal propodosomal setae about 9μ long and 1.3μ wide; second and third pairs each about 24μ long; fourth pair slightly shorter.

Hysterosoma similar to hysterosoma of larva. Sacral setae (Fig. 2) about 30μ long and 3μ wide; other dorsal setae similar in length to second pair of dorsal propodosomal setae. Distances between paired dorsocentral hysterosomal setae: DC_1 79 ± 2μ (range, 77-83μ); DC_2, 54 ± 3μ (range, 48-58μ); DC_3, 34 ± 2μ (range, 32-35μ). Distance between inner sacral setae, 37 ± 3μ (range, 32-45μ).

Length of leg I excluding coxa and tarsal claws, 241 ± 7μ (range, 231-254μ). Lengths of leg I segments: trochanter, 16 ± 0μ (range, 16-16μ); femur, 80 ± 3μ (range, 74-83μ); genu, 38 ± 1μ (range, 35-39μ); tibia, 50 ± 2μ (range, 48-55μ); tarsus, 58 ± 4μ (range, 51-64μ). Leg I 1.4 times longer than leg II, 1.34 times longer than leg III, 1.32 times longer than leg IV. Coxae I and II each with two setiform setae; coxa III with one setiform seta; coxa IV without setae. Trochanters I, II, and III each with one setiform seta; trochanter IV without setae. Tarsus I with two sets of duplex setae; tarsus II with one set of duplex setae on outer dorsal surface; tarsi III and IV without duplex setae. Tarsi I to IV each terminating in a central padlike empodium and a pair of lateral claws. Each empodium and claw with one pair of ventrally-directed tenent hairs; each tenent hair on each empodium supported by four roots; each tenent hair on each claw supported by at least three roots. Setation of leg I shown in Fig. 14.

Deutonymph.—Based on 10 slide-mounted specimens. Body: length, 409 ± 25μ (range, 373-445μ); width 274 ± 39μ (range, 208-323μ); with 16 pairs of minutely spined, lanceolate to spatulate dorsal setae, more uniform in length than in protonymph.

Mediodistal margin of stylophore cleft (Fig. 11).

Propodosoma with granulations on dorsal integument more distinct than in protonymph. Propodosomal lobes (Fig. 7) more regular in shape than in protonymph; median lobes larger and more distinct than tubercle-like lateral lobes. First pair of dorsal propodosomal setae about 12μ long and 1.5μ wide; second pair about 30μ long and 3.5μ wide; third pair slightly shorter; fourth pair shorter and wider than third pair.

Hysterosoma similar to hysterosoma of larva. Sacral setae (Fig. 3) now about same length as second pair of dorsal propodosomal setae. Other dorsal hysterosomal setae somewhat shorter and wider. Distances between paired dorsocentral hysterosomal setae: DC_1 90 ± 4μ (range, 83-96μ); DC_2, 67 ± 3μ (range, 64-71μ); DC_3, 42 ± 3μ (range, 39-48μ). Distance between inner sacral setae, 57 ± 5μ (range, 48-64μ).

Length of leg I excluding coxa and tarsal claws, 325 ± 16μ (range, 299-353μ). Lengths of leg I segments: trochanter, 18 ± 2μ (range, 16-19μ); femur, 114 ± 7μ (range, 103-125μ); genu, 51 ± 2μ (range, 48-55μ); tibia, 70 ± 4μ (range, 64-74μ); tarsus, 72 ± 5μ (range, 64-80μ). Leg I 1.5 times longer than leg II, 1.6 times longer than leg III, 1.3 times longer than leg IV. Coxae I and II each with two setae, the inner ones setiform, the outer ones shorter and either setiform or very

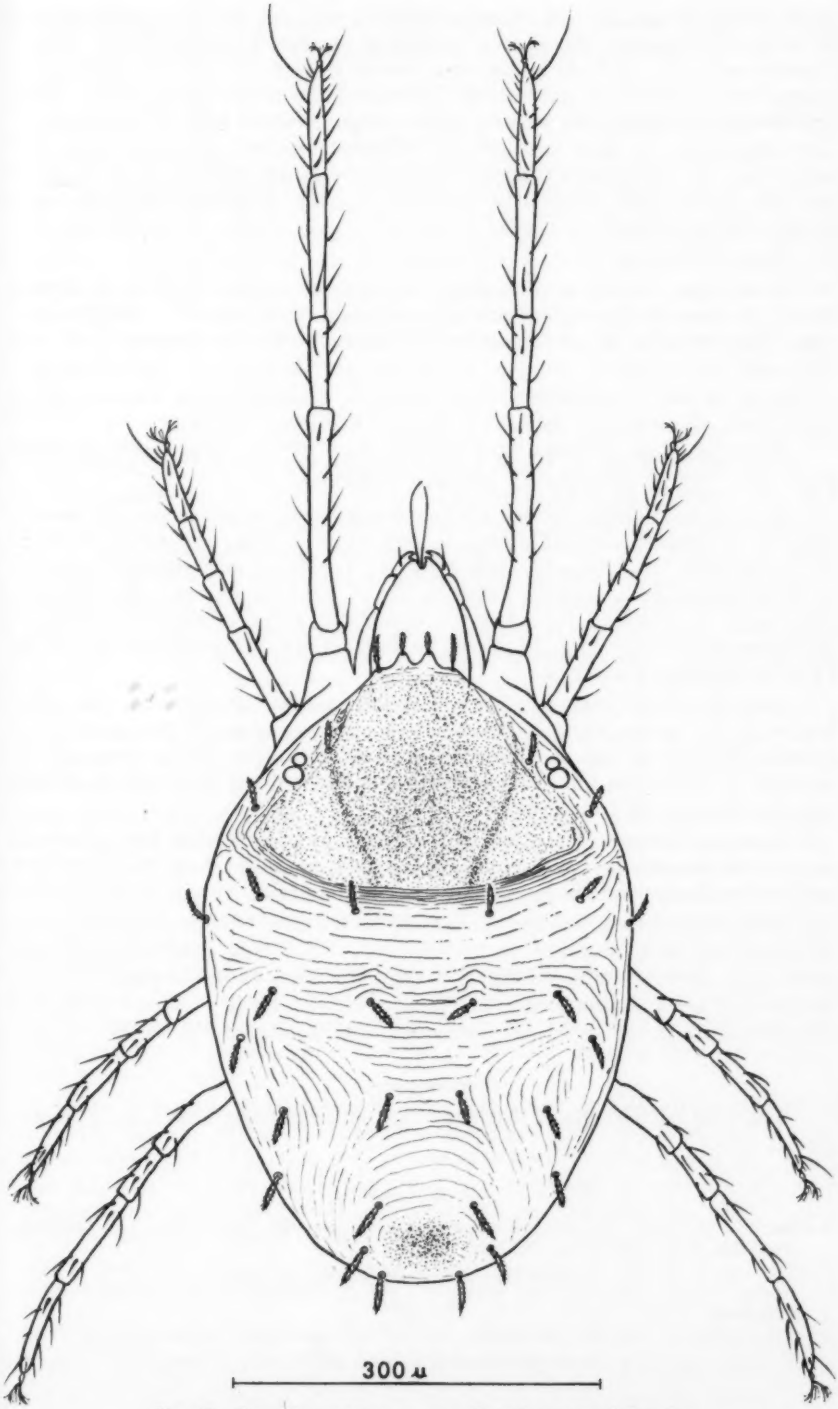


Fig. 17. *Bryobia agropyra*, n. sp. Dorsal aspect of female.

faintly serrate; coxae III and IV each with one setiform seta. Trochanters I to IV each with one seta, the first two setiform, the last two very faintly serrate. Tarsus I with two sets of duplex setae, tarsus II with one set of duplex setae arising from outer dorsal surface; tarsi III and IV without duplex setae. Tarsi I to IV each terminating in a central padlike empodium and a pair of lateral claws. Each empodium and claw with one pair of ventrally-directed tenent hairs; each tenent hair on empodium I supported by four roots, on empodia II to IV by at least five roots; each tenent hair on claws I to IV supported by four roots. Setation of leg I shown in Fig. 15.

Male.—Unknown.

Host Plant.—Beardless wheatgrass, *Agropyron inerme* (Scribn. & Smith) Rydb. Commonly known by livestock ranchers as "bunch grass". Distribution: plains and dry hills, British Columbia to Montana, south to Oregon, Utah, and Nebraska.

Type Locality.—Research Station, Research Branch, Canada Department of Agriculture, Summerland, British Columbia. Elevation 1,600 feet.

Holotype.—Female collected at Summerland, B.C., June 28, 1959, by P. T. Yee. No. ..... in the Canadian National Collection.

Paratypes.—Four females on slide containing holotype, same data; two females collected at Summerland, B.C., Aug. 5, 1959, by P. T. Yee; six females collected at Summerland, B.C., Aug. 25, 1959, by P. T. Yee; three deutonymphs collected at Summerland, B.C., Sept. 2, 1959, by C. V. G. Morgan; two protonymphs collected at Summerland, B.C., Aug. 25, 1959, by P. T. Yee; three larvae collected at Summerland, B.C., Aug. 24, 1959, by P. T. Yee. All paratypes are in the Canadian National Collection.

Diagnosis.—The sharply cleft stylophore readily distinguishes the adult females of *B. agropyra* and *B. curiosa* from other members of the genus. The absence of a dorsal pit or depression between the inner sacral setae and the presence of a granulated integument in the sacral-clunal region of *agropyra* easily separates that species from *curiosa.*

Biological Notes.—The bright red eggs are laid in the duff and in the soil around the bunches of grass. In the laboratory, eggs laid Aug. 6 and 7, 1959, and kept at room temperature, hatched 15 to 18 days later.

Presumably several generations develop each year. On June 28, 1959, when the mite was first observed at Summerland, B.C., only adult females were recovered. During the first week of August, the stages consisted mostly of adult females and a few deutonymphs and protonymphs. Three weeks later most of the mites were in the larval, protonymphal, and deutonymphal stages.

Summary

The four active stages of *B. agropyra*, n. sp. from Summerland, B.C., are described.

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Descriptions of Two Species of *Ceratophyllus* Curtis from Yukon Territory (Siphonaptera: Ceratophyllidae)

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One may well assume that almost all the Nearctic species of mammalian fleas have probably been discovered. Concentrated collecting and study of mammals and their parasites for more than half a century has not only yielded a largely complete roster of the flea species present but has also elucidated the geographical distributions and host associations of many of them. However, this can hardly be said for the bird fleas, which have been relatively neglected. The distributions and ecology of the known species are imperfectly understood and interesting records and new species can still be found, especially in the western and northern parts of the region, if one takes the trouble to search. For example, recent collections from birds' nests in Alaska, made by Dr. Robert Rausch, have yielded a number of distributional surprises (e.g., *Ceratophyllus gallinae* (Schrank), formerly believed to be confined to eastern North America) and examination of the nests of a mere six species of birds by the writer and J. E. H. Martin of the Entomology Research Institute during a brief collecting trip on the Alaska Highway in August, 1959, revealed five species of fleas, all belonging to the genus *Ceratophyllus* Curtis, and including two of special interest. One of these is new to science. The second, identified here as *Ceratophyllus balati* Rosicky, a species recorded in the literature only from Czechoslovakia, is redescribed here for the convenience of North American students, and also to supplement the original description. In addition to describing these, the writer wishes, in this paper, to emphasize the paucity of our knowledge of bird fleas in the hope that ornithologists and others who may find opportunities to collect and examine birds' nests (after the fledglings have left) will search for fleas.

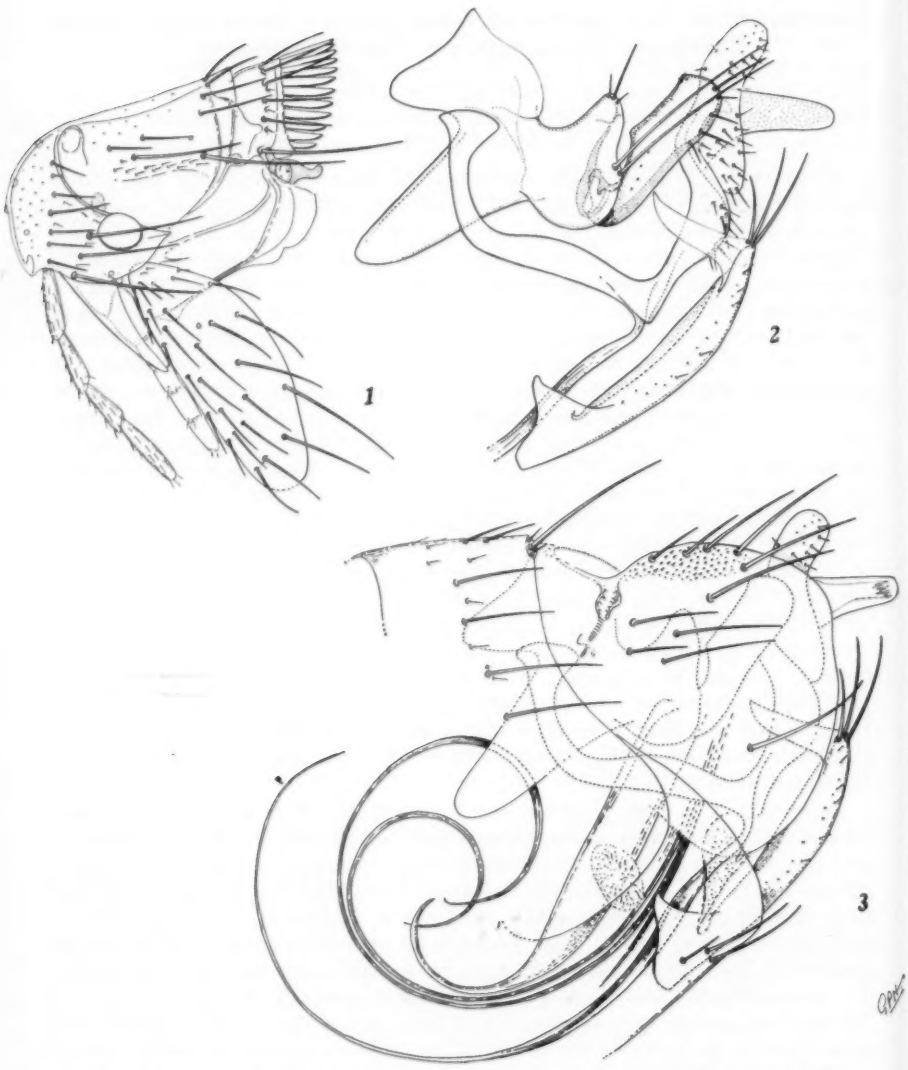
In general it is more profitable (and more humane) to examine birds' nests rather than the birds themselves; and nests on the ground, in burrows, in buildings, and in holes in trees are apt to be more productive than those in more exposed places though, in some humid areas, nests of almost any species of bird many yield fleas. Nests built wholly or partly of mud are often more productive than those woven of grasses only. All species of swallows appear to be prolific breeders of fleas that are rather strongly host-specific, and one kind of swallow may have different species of fleas in different areas of its range. Nests of woodpeckers are of special interest and have not been well investigated, and nests of sea birds, especially those that live in burrows, have hardly been touched in the Nearctic region.

When collected, nests should be placed in paper or cloth bags to prevent escape of fleas, and examined when convenient in a large white enamelled pan, such as a dish pan. The nest may be teased out in the pan, a little at a time. Fleas, if present, will be readily seen, and can be picked up with forceps or a dampened toothpick and placed in vials of 70 per cent alcohol. The writer would be happy to receive collections of bird fleas from any area.

Ceratophyllus balati Rosicky 1955

(Figs. 1-5)

A medium-sized, dark-brown species. Separable from all other known species of the genus by the large, truncate, crochets of the male and the associa-

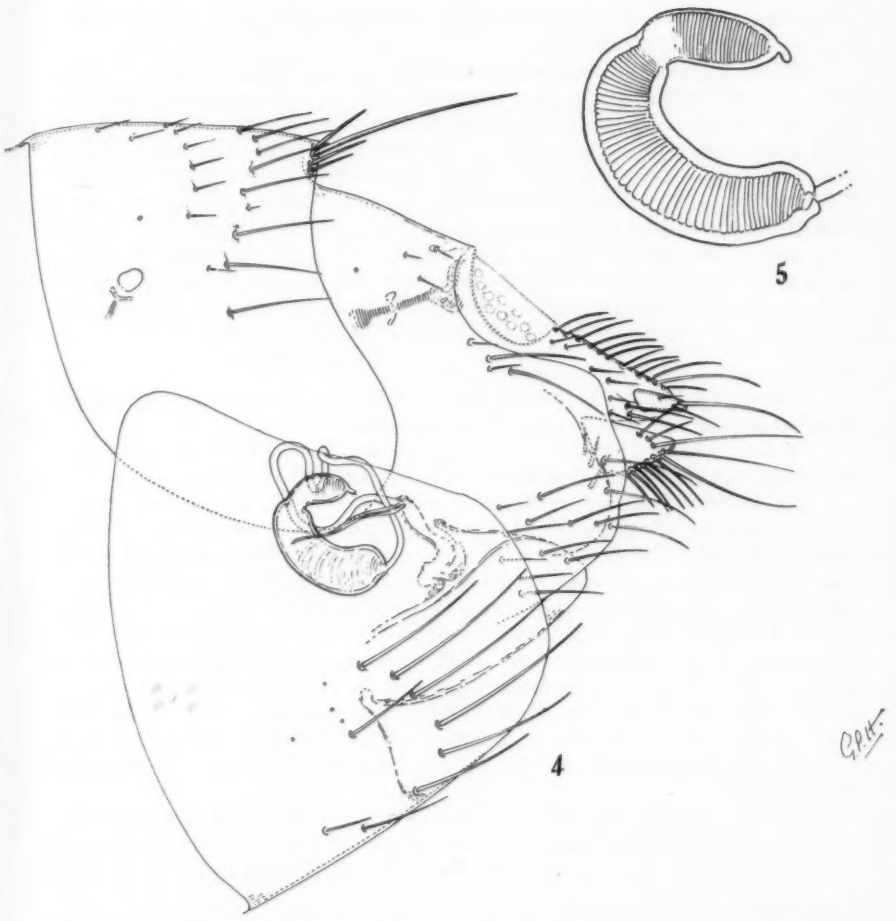


Figs. 1-3. *Ceratophyllus balati* Rosický. 1, Head and prothorax of male. 2, Claspers and sterna VIII and IX of male. 3, Terminal abdominal segments of male.

tion of short penis rods, not completing a convolution, in the male with a sausage-shaped spermatheca in the female. No obvious affinities with any other known species.

Male

Head with ocular row of three long setae and frontal row of about seven fairly long setae (Fig. 1). Anterior and mid-rows of post-antennal region represented by one or two setae each. Clypeal tubercle conspicuous. Eye large and deeply pigmented. Second antennal segment with some bristles more than



Figs. 4-5. *Ceratophyllus balati* Rosický. 4, Terminal abdominal segments of female. 5, Spermatheca.

two-thirds as long as club. Labial palpus about two-thirds as long as fore coxa.

Pronotum with 12-13 long, heavy spines per side. Mesonotum with about five slender pseudosetae per side. Collar of metanotum not reduced. Remaining thoracic elements much as in most species of *Ceratophyllus;* pleural ridge of metathorax strongly developed, terminating in a bulblike expansion enclosed by a pleural arch.

Legs well developed; posterior margin of hind tibia with stout setae well developed except for the first, third, and sixth pairs.

Typical abdominal spiracles nearly circular and not appearing doubled up. Typical abdominal terga each with a row of about seven long setae reaching approximately to the spiracle. A shorter row of five to seven shorter setae anteriorly, and occasional short setae anterior to these again, forming part of a third row. Apical spinelets on abdominal terga as follows: I, 2 or 3 (rarely

1) per side; II, 3 or 2 (rarely 1); III, 2, (sometimes 3); IV, 2 (rarely 1 or 3); V, 0 (sometimes 1, rarely 2).

One long antesensilial seta with one or two minute hairs at its base. Tergum VIII with about four strong setae along the dorsal margin and about six laterally (Fig. 3). A spiculose area on the inner dorsal surface of tergum VIII. Sternum VIII wide, especially in the middle, with about three pairs of strong apical setae and a pair of broad, bladelike, membranous flaps, not fringed posteriorly. Clasper with processes shaped somewhat as in *C. gallinae* (Schrank) but the movable process with short setae only on its posterior margin (Fig. 2) and a long one at the apex. Sternum IX as shown (Fig. 2). Crochet of aedeagus large and broadly rounded at apex. Penis rods and tendons of aedeagal apodeme and sternum IX short and not completing a convolution as in the *garei* group of the genus, to which this species nevertheless does not belong.

Female

Chaetotaxy of head as in male, but frontal row of setae somewhat weaker. Setae of second antennal segment exceeding club.

Pronotal comb with about 14-15 spines per side. Other details of thorax and pregenital segments of abdomen approximately as in male.

Usually three and sometimes four antesensilial setae, the second very long (Fig. 4) and the others short. Tergum VIII with about 16 medium or longish setae ventrolaterally; about two or three short, stout setae on inner surface, near posterior margin. Anal stylet with a long apical seta, and two medium setae; stylet slightly more than twice as long as wide. Sternum VII broadly rounded with no trace of a sinus. Spermatheca (Fig. 5) somewhat like that of *C. gallinae*, the head being parallel-sided or sausage-shaped, but broader in proportion to its length than in many other species of the genus. Tail of spermatheca with well-developed papilla. Duct of spermatheca short, in association with the short penis rods; proximal portion of the blind duct strongly sclerotized.

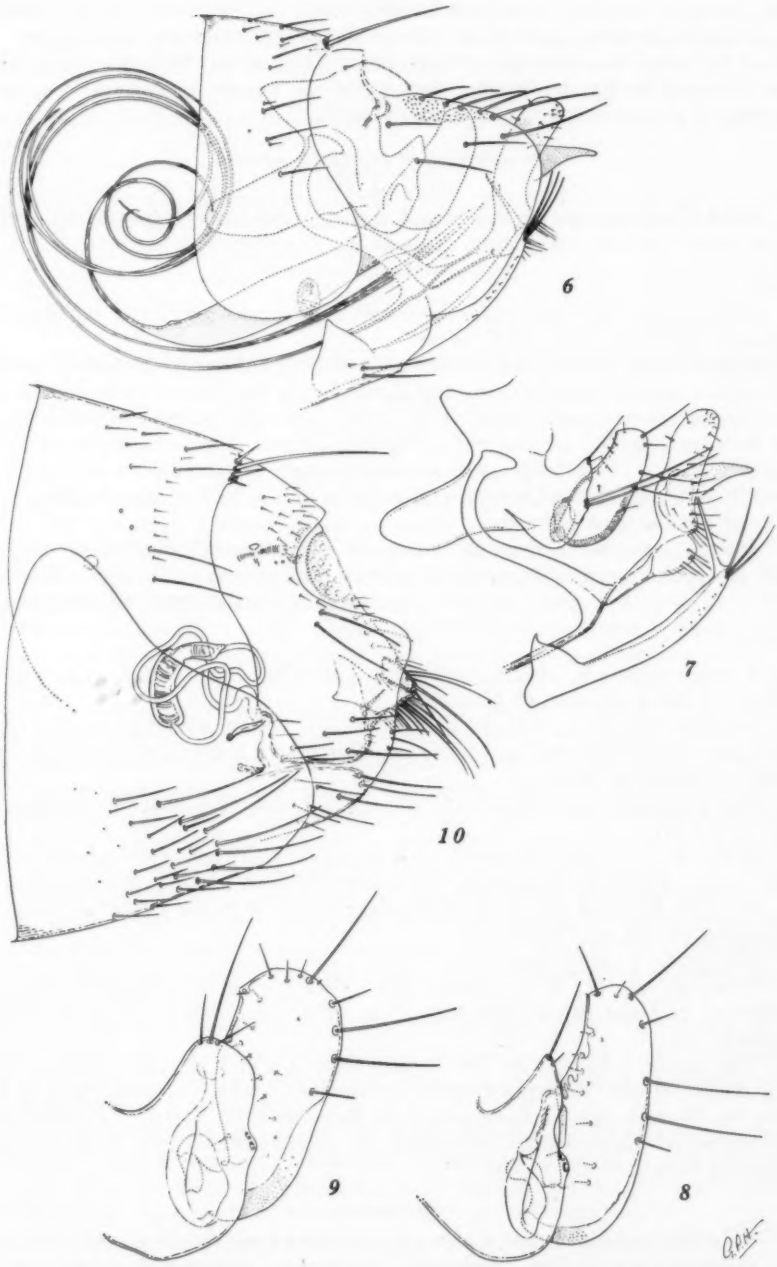
Size (mounted specimens): ♂, average 3.1 mm. (2.8-3.2); ♀, average 3.3 mm. (3.1-3.5).

Record: Mile 84, Haines Highway, Yukon Territory, August 14, 1959; 23 ♂♂, 23 ♀♀, collected from the vacated nest of Say's phoebe, *Sayornis saya yukonensis* Bishop, in a deserted army hut, by G. P. Holland and J. E. H. Martin.

Comments

C. balati was originally described from a single male specimen collected in the High Tatra of Czechoslovakia from a water pipit, *Anthus spinoletta* L. Mr. F. G. A. M. Smit of the Zoological Museum, Tring, kindly informed the writer (*in litt.*) that the Hon. Miriam Rothschild collected a series of the same species from the nests of choughs, *Pyrrhocorax graculus* L., at Niesen, Bernese Alps, Switzerland, in 1953. Smit was able to compare this series with the holotype and later, with specimens from Canada. As he observed, there are small, and possibly constant, differences between Swiss and Yukon males of *balati* that might warrant the recognition of a Nearctic subspecies. These differences, the only ones observed, involved sterna VIII and IX, the membranous flap of the former being apical in Nearctic, and somewhat preapical and broader at the base in Palaearctic, specimens. Sternum IX of Nearctic males of *balati* have the apex of the dorsal arm broadly expanded and flattened (Fig. 2) rather than only slightly expanded and rounded.

The writer considers that a decision on the question of subspecies should be deferred, pending further collections, especially from areas lying between the widely separated localities from which it is now known, and points out that at



Figs. 6-8, 10. *Ceratophyllus rauschi* n. sp. 6, Terminal abdominal segments of male. 7, Claspers and sterna VIII and IX of male. 8, Enlarged detail of processes of clasper. 10, Terminal abdominal segments of female. Fig. 9. *Ceratophyllus niger* Fox, Processes of clasper (Victoria, B.C.).

least one other bird flea, *Ceratophyllus garei* Roths., is distributed widely through the Holarctic Region, apparently without significant geographical variation. It should be noted, too, that the species of bird from which the type of *C. balati* was collected in Czechoslovakia, occurs also in North America where, until recently, it was known as the "American pipit".

Ceratophyllus rauschi new species

(Figs. 6-8, 10)

Near *Ceratophyllus niger* Fox but smaller; readily distinguished by details of the male, but not the female, genitalia.

Male

Morphology and chaetotaxy of head, thorax, and pregenital segments of abdomen similar to those of *C. niger*.

Apex of fixed process of clasper sharply pointed rather than broadly rounded, and with a distinct concavity on the distal margin between the "lock" and the insertion of the acetubular setae (Figs. 8, 9). Movable process relatively wide and broadly rounded at base but narrowing (rather than broadening as in *C. niger*) apically. Two long setae on distal margin and another near apex. A sharp "tooth" on anterior margin that engages in the lock of the fixed process. Crochet narrow and pointed.

About five (rather than 10) marginal and submarginal setae on tergum VIII, and the inner spiculose area not so well developed as in *C. niger*. Sternum VIII as in *niger* but apical membranous flap somewhat shorter and narrower.

Female

Though generally smaller and with somewhat fewer setae, not reliably distinguishable from that of *C. niger*.

Sternum VII entire, without sinus (Fig. 10). Spermatheca of narrow type. Blind duct well sclerotized and bursa copulatrix with a dorsal marginal sclerotization at orifices of ducts.

Size (mounted specimens): ♂, average 2.5 mm. (2.4-2.6); ♀, average 2.6 mm. (2.2-3.1).

Holotype.— ♂, 30 miles north of Stewart River Crossing on Alaska Highway, Yukon Territory, August 16, 1959; collected from nest of a flicker, *Colaptes* sp., by G. P. Holland and J. E. H. Martin; No. 7154 in the Canadian National Collection of Insects, Ottawa.

Allotype.— ♀, same data.

Paratypes.—2 ♂ ♂, 10 ♀ ♀, same data. Paratypes in the Canadian National Collection and the British Museum (Nat. Hist.), Zoological Museum, Tring, England.

The species is named for Dr. Robert Rausch, Chief, Zoonotic Disease Section, Arctic Health Research Center, Anchorage, Alaska. During the past ten years Dr. Rausch and his colleagues have been most co-operative in collecting Alaskan fleas, making efforts, on request, to obtain material from hosts or areas of special interest to the writer.

Summary

Two species of bird fleas, *Ceratophyllus balati* Rosicky and *C. rauschi* n. sp., are described from Yukon Territory. The former, collected from the nest of Say's phoebe, differed slightly from Czechoslovakian and Swiss specimens in minor features of the male genitalia but the decision to recognize a nearctic subspecies was deferred. The latter was collected from the nest of a flicker.

Acknowledgment

The contribution of Mr. F. G. A. M. Smit, Curator of the Rothschild Collection of fleas at the Zoological Museum, Tring, Herts., England, is gratefully acknowledged. Besides providing notes on the type of *C. balati*, he presented Swiss specimens of the species to the Canadian National Collection of Insects.

Reference

Rosický, B. 1955. Die Aphanipterofauna der Hohen Tatra mit Anmerkungen über die Höhenverteilung der Flöhe in diesem Gebirge [in Czech with German summary]. *Zool. Ent. Listy* 4: 365-383; 8 figs.

(Received March 30, 1960)

Some New and Little-Known North American Tabanidae (Diptera)

By L. L. PECHUMAN
Lockport, New York

***Silvius pollinosus jeanae*, new subspecies**

Casual examination of a series of three *Silvius* would indicate they are distinct from any described species. Examination in detail, however, shows a close relationship to *S. pollinosus* Williston. Since the material on hand is limited, it is probably better to regard them as representing a subspecies of *pollinosus* than to give this new form full specific rank.

Holotype, female, 9 mm. Front yellowish-gray-pollinose; frontal callus shining dark brown, wider than high, very small, about same size as bare areas around frontoclypeal pits. First two antennal segments yellow with black hairs, slightly darker apically; third antennal segment black, reddish brown at base. First palpal segment yellow; second segment fuscous, yellowish at base. Integument of mesonotum black, grayish-pollinose with five pale-gray longitudinal stripes; scutellum black, grayish-pollinose. Pleurae yellowish-gray-pollinose with a scattering of pale hairs. Coxae fuscous; femora, tibiae and metatarsi yellowish, dark brown at apex except hind femora which are yellow brown on basal half and dark brown on apical half; tarsi dark brown, yellow-brown at base. Knob of halteres dark brown. Wings as figured. Abdomen yellowish gray, with yellowish cast most intense laterally on first two tergites and posteriorly on each segment; third and fourth tergites each with a small shining black spot on the anterior margin on either side of the median line. Venter more yellowish than dorsum and without black spots.

Naval Air Station, Corpus Christi, Texas, 1 July 1943. (W. M .Gordon). In writer's collection. Paratypes: Kingsville, Texas (C. T. Reed); Blythe, Riverside Co., California, 4 July 1947 (W. F. Barr). Later paratype in collection of Washington State University.

The general yellowish cast of this form immediately distinguishes it from *pollinosus*, which is gray; the frontal callus is much smaller than in *pollinosus* and the wing spots are larger and more intensely colored; the marginal infuscation near the tip of the wing is more extensive than in *pollinosus*.

The Blythe, California, paratype (10 mm.) is especially yellowish, the frontal callus is larger than in the holotype and the dark spot at the distal end of the discal cell is broken into two spots by a small hyaline area at the base of the third posterior cell. The frontal callus of the Kingsville, Texas paratype (8 mm.) is smaller than the holotype and about as high as wide, tapering above;

the wing spots and marginal infuscation are heavier than in the holotype. In the holotype, the dark spot at the bifurcation of the third longitudinal vein in the left wing is more extensive than in the right wing which is figured.

Silvius (*Zeuximyia*) *philipi* Pechuman

Silvius philipi, for which the monotypic subgenus *Zeuximyia* was later erected by Philip (1941), was described from a single female by the writer (1938). Since that time only one other specimen, also a female, has been reported (Middlekauff, 1950; Philip, 1954). The type was from ten miles southeast of Lebanon, Oregon, and the second female was from Humboldt Co., California. The appearance of a male, also from northern California, of this unusual species is therefore of interest. Through the cooperation of Prof. Maurice T. James, Washington State University and Mr. H. J. Teskey, Entomology Laboratory, Canada Department of Agriculture, Guelph, Ontario, the writer was able to study this specimen. Collection data on the specimen: Eel River Camp, Mendocino Co., California, 7 July 1948 (U. N. Lanham).

Male, 7 mm. Antennae black with black hairs; proportions of segments same as in female. All facial area below antennae somewhat swollen. Frontal triangle gray-pollinose; frontoclypeus thinly gray-pollinose with two denuded black spots near lateral pits; center of frontoclypeus and lower portions of cheeks so thinly pollinose that brown integument shines through; hairs long and white. Second palpal segment dark brown, somewhat clavate, with long white hair. Ocellar area blackish brown. Large facets of eye occupying about upper three quarters of eye, line of demarcation from small facets distinct.

Mesonotum subshining black, brown above wing bases, thinly covered with long white hairs; traces of two gray lines anteriorly. Pleurae dark with gray hairs. Knob of halteres brown. Legs mostly yellowish brown; all coxae dark; apex of all femora and tibiae darkened, least so on middle pair; tarsi, except basal half of middle and hind metatarsi and basal third of front metatarsi, dark. Wings similar to those of the female holotype. Costal cell not so heavily infuscated and infuscated area near tip of second vein less extensive; infuscated area below stigma in first submarginal cell more extensive and joined to a darker area, along the third vein, which is not present in the female holotype; what is a minute dot in the female on the vein separating the third and fourth posterior cells is expanded in the male to cover the basal half of the vein and is joined to the spot at the distal end of the discal cell.

First abdominal segment black, a trace of brown sublaterally along the posterior border; second segment black, somewhat brownish laterally, with a narrow grayish-brown posterior border which expands to form indistinct median and sublateral triangles; third and fourth tergites similar to second but pale border broader and triangles more obscure; fifth and sixth tergites black with a wide pale posterior border. Black of first four segments subshining; black of fifth and following segments shining. First four sternites gray; fifth and following sternites shining black with a gray posterior border.

Although the male is considerably smaller than the holotype and differs slightly in wing pattern, the writer believes he has correctly associated this specimen.

Hybomitra frosti, new species

Holotype, female, 12.5 mm. Head relatively small. Eye with fine short hair, in life purple with three distinct green bands and traces of a fourth near the top of the eye. Front essentially parallel-sided, 2½ times as high as width

at base, grayish-pollinose with a golden cast on each side of median callus, with scattered black hairs; callosity dark brown, almost black, rectangular, wider than high, touching eyes below; median callus black, oval, contracting above to a narrow line; ocellar tubercle brown. Subcallus thinly yellow-gray-pollinose with dark-brown integument shining through especially laterally. Clypeus and genae gray-pollinose with many white hairs and a few black hairs above on genae. First two antennal segments dark reddish brown; third antennal segment reddish brown on basal third grading to dark brown, annuli black; third antennal segment rather narrow, scarcely excised above, with dorsal angle obtuse. Second palpal segment slender, acutely pointed, slightly thickened at "knee", brownish at base grading to yellow at apex; hairs stiff, black, somewhat porrect giving a shaggy appearance. Proboscis only slightly longer than palpi.

Mesonotum dark brown, with black and pale hairs; five pale stripes on mesonotum of which the central one is very narrow and pale brown, sublateral stripes gray and lateral stripes with a pink cast; prescutal lobe pinkish; scutellum deep brown. Pleurae gray with pale hairs. Wing veination normal; a trace of a spur at bifurcation of third longitudinal vein; a trace of infuscation at crossveins and bifurcation; costal cell rather deeply tinted. Knob of halteres dark brown. Legs mostly brown; apical third of fore tibiae, basal third of middle femora, basal half of hind femora and tarsi dark brown, almost black. All coxae and hind femora with pale hairs; all hairs of hind tibiae black.

Abdomen blackish brown with mostly black hairs; first segment darker in center and on lateral margins, somewhat paler laterally on posterior border of segment; second and third segments with a pale mid-dorsal triangle reaching the anterior border and with pale oblique sublateral spots; remaining tergites similar but pale areas reduced; tufts of pale hairs are present where pale areas reach posterior margins of segments. Venter gray with a pink tinge, pale hairs and very narrow pale hind margins on segments; an indistinct dark gray longitudinal stripe with black hairs runs down mid line of venter.

Orrville, Ontario, 31 July 1959 (L.L.P.)

Allotype male, 11 mm. Similar to female except for usual sex differences. Eye facets scarcely differentiated. Third antennal segment even more narrow than female and reddish color restricted to extreme base. Black hairs mixed with white hairs of clypeus and genae. Second palpal segment small, subequal to first, somewhat clavate, slightly more than twice as long a diameter at center, brownish, yellowish at apex. Mesonotum subshining with long black and gray hairs; pale stripes narrower than in female and central and sublateral stripes do not reach the posterior margin. Legs as in female except basal half of middle femora almost black and middle and hind tarsi paler brown. Abdominal markings as in female but sublateral spots on second and third tergites with a pinker cast; venter somewhat darker.

Same data as holotype. The exact locality for the holotype and allotype is a sphagnum bog bordering a small unnamed lake the southern border of which is 1,800 feet north of Day's Lake, Lot 17, Monteith Township, Parry Sound District, Ontario.

Paratypes: ONTARIO: Orrville, 19, 22 July 1955, 27 August 1960, 3 ♀♀ (L.L.P.). QUEBEC: Laniel, 10, 16 August 1939, 2 ♀♀ (J. L. Hitchon). NEW BRUNSWICK: Fredericton, 27 July, 10 August 1922, 2 ♀♀. NOVA SCOTIA: Baddeck, 21 July 1936, 1 ♀ (J. McDunnough); West Dover, Halifax Co., 12 September 1957, 2 ♀♀ (D. C. Ferguson). MAINE: Patten, 23 July 1937, 1 ♀.

PENNSYLVANIA: Tamarack, 31 July 1957, 2 ♀♀, 2 ♂♂ (S. W. Frost); Tamarack Swamp, Clinton Co., 12 August 1958, 1 ♀ (R.L.C.).

Holotype and allotype in writer's collection. Paratypes in Canadian National Collection, U.S. National Museum, Nova Scotia Museum of Science, Pennsylvania State University and the collection of C. B. Philip.

I take pleasure in naming this species for my friend Professor Emeritus S. W. Frost of Pennsylvania State University who first collected both sexes of this species.

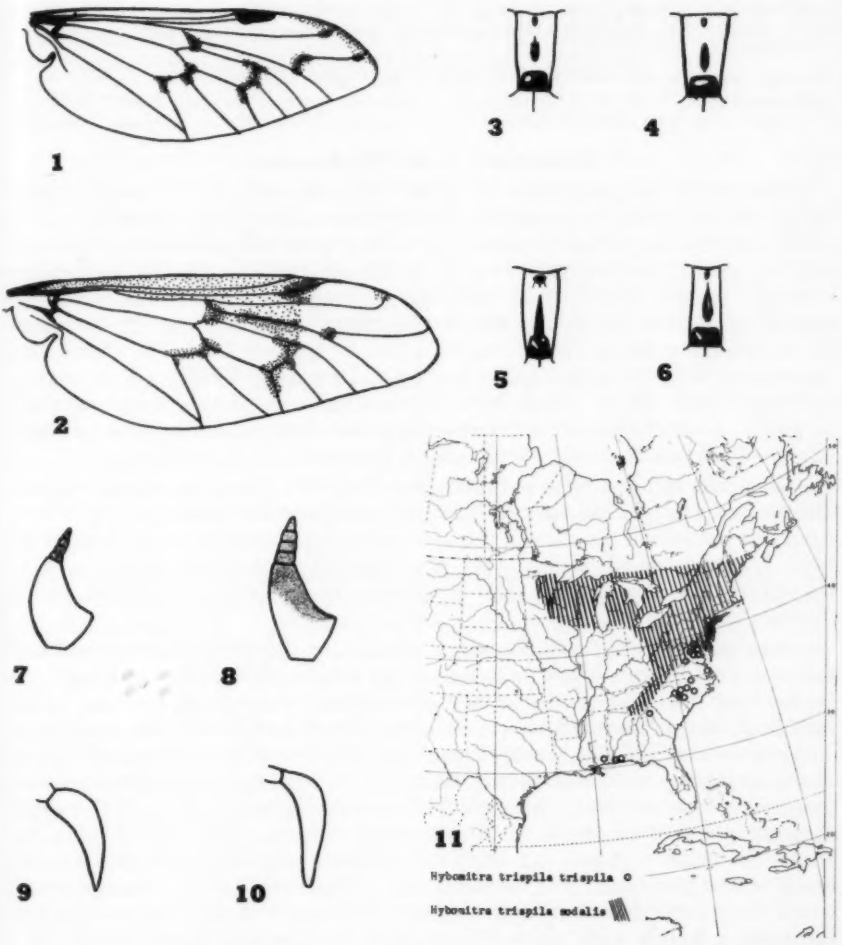
There is very little variation in the series of paratypes except in length which varies from 12 to 15 mm. In some specimens there are a few white hairs on the base of the palpi and on the hind tibiae and in some specimens the dark mid-ventral band is not present or is indicated only by dark hairs. A few specimens have the costal cell darker than in the holotype. The two paratype males have the second palpal segment more thickened apically than in the allotype.

Hybomitra frosti apparently has obscure habits and is seldom collected. Both holotype and allotype were swept from sphagnum. The 12 August 1958 Tamarack specimen is labeled "on wild carrot" and the two West Dover specimens are labeled "at moth bait at night". One of the 1955 Orrville specimens was collected by the writer as it slowly flew near his ankle, apparently with no serious intention of biting.

H. frosti belongs to a difficult group of species which includes *typha* (Whitney), *astuta* (O.S.), *itasca* (Philip), *hearlei* (Philip), *microcephala* (O.S.). Possibly *boreus* (Stone) is a connecting link between this group and the *frontalis* group. *H. frosti* is more closely related to *astuta* and *itasca* than to others in the group. *H. astuta* is distinguished in both sexes by completely dark hind femora and black prescutal lobe; *itasca* has a broader front usually slightly widened above, completely brown hind femora, more tapering palpi with the hair lying flat, pale brown frontal callus, mostly white hind tibial fringe and hyaline costal cell.

The following key should serve to distinguish all members of this group including an anomalous form of *typha*. The males of *itasca*, *hearlei* and *boreus* are unknown.

1. Dioptic (females) 2
   Holoptic (males) 9
2. Prescutal lobe black; third antennal segment black; palpi white with white and black hair; a black species with sharply contrasting pale gray markings ..... *boreus* (Stone)
   Not with above combination of characters 3
3. Prescutal lobe black; hair of palpus long, uneven and semi-erect 4
   Prescutal lobe pale; hair of palpus as above or short and lying smoothly against segment 6
4. Proboscis long, palpus not reaching base of labellae ..... *hearlei* (Philip)
   Proboscis short, subequal in length to palpi or slightly longer 5
5. Legs brown; palpi swollen at base; third antennal segment very narrow; front narrow with callus slightly higher than wide ..... *microcephala* (O.S.)
   Legs mostly black; palpi narrow at base; third antennal segment moderately narrow; front broader with callus slightly wider than high ..... *astuta* (O.S.)
6. Front about twice as high as wide; frontal callus pale brown; femora brown; costal cell clear ..... *itasca* (Philip)
   Front more than twice as high as wide; callus brown to black; femora rarely dark brown, usually at least partly black; costal cell infuscated 7
7. Hair of palpi long and uneven, semi-erect; base of third antennal segment narrow; hind femora black on basal half, balance brown ..... *frosti* n. sp.
   Hair of palpi short and lying smoothly against segment; base of third antennal segment not very narrow; hind femora brownish to completely black 8



Figs. 1-11. 1, Wing of *Silvius pollinosus jeanae* ♀; 2, Wing of *Silvius* (*Zeuximyia*) *philipi* ♂; 3-6, Frons of ♀: 3, *Hybomitra astuta;* 4, *H. itasca;* 5, *H. microcephala;* 6, *H. frosti;* 7, 8, Third antennal segment of ♀: 7, *Hybomitra trispila trispila;* 8, *H. trispila sodalis;* 9, 10, Palpus of ♀: 9, *Hybomitra trispila trispila;* 10, *H. trispila sodalis;* 11, Distribution of *Hybomitra trispila.*

8. Femora brown or partly black; frontal callus brown; palpi slightly swollen at "knee" and tapering acutely to a point ..... (Form A) ..... *typha* (Whitney)
   Femora black; frontal callus black or dark brown; palpi slender but not acutely tapered from "knee" ..... (Form B) ..... *typha* (Whitney)
9. Prescutal lobe and humeral callus black and concolorous with mesonotum; eye facets scarcely differentiated 10
   Prescutal lobe and humeral callus pale and contrasting with adjoining portions of mesonotum; eye facets variable, often distinctly differentiated 11
10. Femora brown; palpi swollen at base and tapering to an acute tip..... *microcephala* (O.S.)
    Femora black; palpi small, not swollen at base, not with an acute tip..... *astuta* (O.S.)
11. Head relatively small; eye facets scarcely differentiated; second palpal segment brown, paler at apex, somewhat clavate; hind femora brown, basal half darkened.... *frosti* n. sp.

Head relatively large; eye facets rather distinctly differentiated; second palpal segment yellow to brown, rather cylindrical; hind femora variable, often completely black 12

12. Legs mostly brown; hind femora darker at base; palpi yellowish ..... (Form A) *typha* (Whitney)

Legs mostly black; palpi brownish ..... (Form B) *typha* (Whitney)

***Hybomitra trispila* (Wiedemann)**

The writer has recognized for many years that two forms were included under *trispila*. A dark-winged form is found from Long Island south at least to South Carolina east of the Appalachians while a paler-winged form occupies the northern part of the range reaching south through the Appalachians to northern Georgia. It was assumed that variations in wing infuscation were within the normal variation of the species, but more intensive study of about 300 specimens has shown other distinctive characters which are quite stable. The distribution of the two forms is distinct throughout most of the range but there is an overlap on Long Island, Staten Island, New Jersey, Delaware, Maryland and northern Virginia. Even in these areas distinguishing characters remain constant and only one specimen has been seen which might be considered intermediate.

The paler-winged form is found from Delaware north to Maine, southern Quebec and Ontario and west to Minnesota and northeastern Iowa. Specimens from every state and province in this area, including individuals from some of the New England coastal islands, have been studied. Specimens have also been studied from the Appalachian areas of Virginia, West Virginia, Tennessee, North Carolina and Georgia.

As a result of this study the writer decided, on the basis of distinctive characters and range, that separation at least at the subspecific level was indicated. A study of the type male of *trispila* Wiedemann loaned through the courtesy of Dr. Max Beier of the Naturhistorisches Museum, Vienna and two female syntypes of *Tabanus sodalis* Williston loaned through the kindness of Prof. George W. Byers of the University of Kansas, showed that creation of a new name was not necessary. Wiedemann's type male, which now lacks antennae, is the dark-winged form and Williston's *sodalis* is the pale-winged form. The type locality for *trispila* "Kentucky" would not be in the expected range of *trispila* and it could easily be that it is from some other locality. Townsend (1955) does not report either form from Kentucky. It may be mentioned that Wiedemann's second specimen, a female, with which he compared his type male is not *trispila* but a species of *Tabanus* s. str.

An excellently preserved syntype of *sodalis* labeled "7 Conn. 17" is hereby designated as lectotype and so labeled. It is assumed this specimen is from Connecticut collected July 17. A second syntype labeled "White Mts." lacks wings and third antennal segments but is obviously the same as the lectotype. Probably at this time *sodalis* should be considered a subspecies of *trispila* although future studies may show it to be specifically distinct.

Females of *trispila* may be separated from *sodalis* not only by the uniformly darkened wing, but also by palpi thicker at "knee" and more acultely pointed, base of third antennal segment proportionally broader and less strongly excavated and third antennal segment sharply bicolored, with basal plate orange and annuli black. In over 200 *sodalis* studied, only one specimen showed no darkening of the basal plate. There is also in typical *trispila* a tendency for the pale pleural hairs to be more extensive and brighter-colored and for the venter to be paler laterally so the mid-ventral dark stripe is very conspicuous. The male of

trispila differs from the male of *sodalis* in the same wing and antennal characters as the female. Also the line of demarcation between small and large eye facets is fairly distinct rather than the gradual merging found in *sodalis*.

The writer has studied specimens of typical *trispila* from the following localities:

NEW YORK: Wyandanch (Long Island), Huguenot (Staten Island). NEW JERSEY: Browns Mills, Franklinville, Glassboro, Jamesburg, Lakehurst, Ridgewood, Riverton, Tabernacle. DELAWARE: Frederica, Millsboro, Sussex Co. MARYLAND: Beltsville, Bladensberg, Camp Meade, Odenton. VIRGINIA: Alexandria, Falls Church, Glencaryln, Nelson Co., Upton, Virginia Beach. NORTH CAROLINA: Candor, Laurel Hill, Pikeville, Raleigh, Southern Pines, Wake Co., West End, Wise. GEORGIA: Yonah Mt. FLORIDA: Bratt. ALABAMA: Baldwin Co. MISSISSIPPI: Lucedale.

The population of *trispila* in western Florida and southern Alabama and Mississippi may be isolated from the main population. The writer has been unable to locate any specimens or find any records for *trispila* taken between southeastern North Carolina and extreme northwestern Florida except for a single specimen from northern Georgia. It has been impossible to locate the specimen or specimens on which McGregor and Schomberg based their record of *trispila* from Texas.

For the loan of the extensive *Hybomitra trispila* and *trispila sodalis* material studied, the writer is indebted to Prof. Henry Dietrich and Mr. Gordon Neilson, Cornell University; Dr. J. F. McAlpine, Entomology Research Institute, Ottawa; Dr. Elton J. Hansens, Rutgers University; Dr. Alan Stone, U.S. National Museum; Prof. Josef N. Knull, Ohio State University; Dr. Eugene Pickard, Tennessee Valley uthority; Mr. Harold J. Grant, Jr., The Academy of Natural Sciences of Philadelphia; Dr. Donald MacCreary, University of Delaware; Prof. David A. Young, North Carolina State College; Dr. D. L. Wray, North Carolina Department of Agriculture; Dr. Harry D. Pratt, U.S. Department Health, Education and Welfare. The writer also appreciates the efforts of the following in trying to locate specimens of *trispila* from Texas: Dr. R. C. Bushland, U.S. Agricultural Research Service, Kerrville, Texas, Prof. D. E. Howell, Oklahoma State University, Mr. W. S. McGregor, Lake Jackson, Texas and Prof. H. J. Reinhard, Texas Agricultural Experiment Station, College Station, Texas.

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(Received July 16, 1960)

Book Review

Histological and Histochemical Studies on the Ovary of the American Cockroach *Periplaneta americana* (L.), by Philip F. Bonhag*, Univ. of Calif. Pubs. in Entom., Volume 16, No. 3, pp. 81-124, pls. 10-17, 1 chart in text. University of California Press, Aug. 14, 1959. Price $1.00.

This is the third species on which Bonhag has concentrated his flair for revealing the finer structure of the insect ovary. The paper is a contribution to the general problem of vitellogenesis which Bonhag recently reviewed (Annual Review of Entomology, Vol. III). The panoistic ovariole of *Periplaneta americana* (L.) was separable into six zones on the basis of observations on syncytial tissue, follicular cells, nucleolar emission bodies, oogenesis, cytochemical waxing and waning of deoxy-, and ribose-, nucleic acid and deutoplasmogenesis. Among a variety of stains, the metachromatic dye azure B was used to advantage. The lack of physical continuity in a sequence of events associated with nucleolar emission bodies (periodic acid-Schiff negative, ribosenucleic acid positive, Feulgen negative) and the appearance of protein yolk precursor bodies (periodic acid-Schiff positive, ribosenucleic acid negative) lead him to suggest the latter bodies arise independently. This interpretation will likely to be more widely accepted than the theories of the origin of protein yolk precursor bodies from mitochondrial fragments or nucleolar emission bodies. A chart depicting ribosenucleic acid levels in zone IV is not informative, particularly in view of the observation that high levels of the acid occur in zone III. Future development of this work must take greater cognizance of the role of ribosenucleic acid in protein synthesis. Cytologists will find the contribution interesting on many other accounts. For example, the observation of four diplotene stages in oogenesis contrasts greatly with the well-known absence of diplotene and diakinesis in the spermatogenesis of *P. americana*. The readers of this and other contributions made by Professor Bonhag will sense the loss to science occasioned by his death at 36 years of age.

J. G. Robertson

*Deceased November 1, 1959.

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